



**1001
FACTS**
about our
world

THE BIG BOOK OF TOP 10s

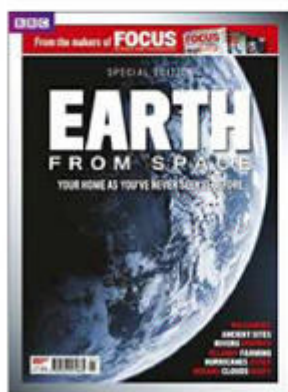
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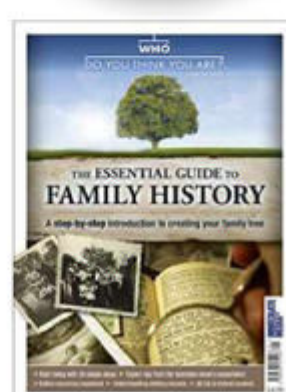
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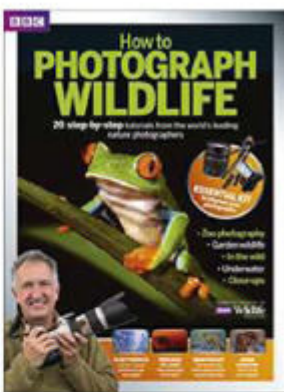
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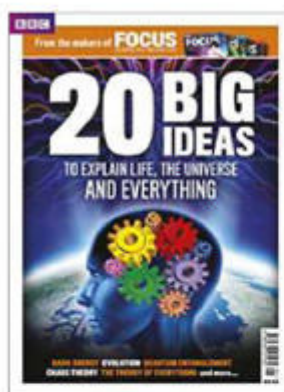
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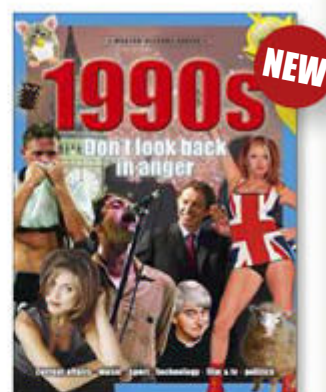
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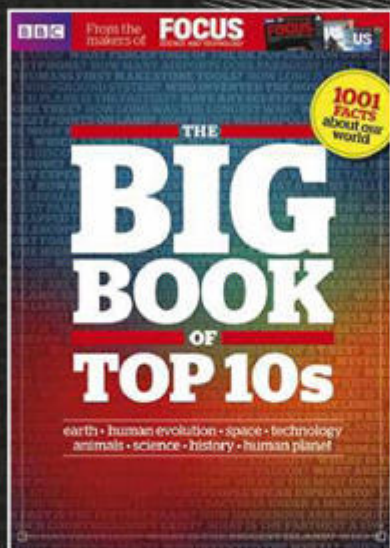
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WELCOME...



My fingers and toes no longer existed. At least, I couldn't feel them. After a few hours enduring a temperature of -10°C in northern Norway, I was ready for the warm embrace of my hotel. Just a few weeks earlier, locals told me they'd endured lows of -30°C . It got me thinking - just what is the coldest temperature on Earth?

You don't have to experience extremes to be gripped by the spirit of enquiry. When you see a skyscraper on TV you might wonder: what's the tallest? Read about a centenarian's birthday and you'll think: who's older, and by how much? Watch a fireworks display and ponder - what makes the biggest bangs? And just how big are they?

You'll find the answers to all these, and many more conundrums, inside this - *The Big Book of Top 10s*, from *BBC Focus* magazine. It's more than just lists, of course. Each section is lavishly illustrated with graphics and photos to put the facts in their proper context. And since *BBC Focus* is a popular science magazine, we've included more besides basic records. Here are the sci-fi predictions that came true, inventors killed by their own inventions, the most expensive experiments and the biggest scientific blunders. It's educational. Or it's a way to liven up dull dinner parties. Or both.

So what is the coldest place on Earth? As it happens, it's a ridge near Dome Fuji in Antarctica, where the mercury can plunge to -93.2°C . I wouldn't want to go. I'd much rather be here, in a cosy armchair, reading *The Big Book of Top 10s*.

Graham

Graham Southorn, Editor

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While every attempt has been made to ensure that the content of *The Big Book of Top 10s* was as accurate as possible at time of press, we acknowledge that some information contained herein may have since become out of date. Also, the content of certain sections is occasionally subject to interpretation; in these cases, we have favoured the most respected source.

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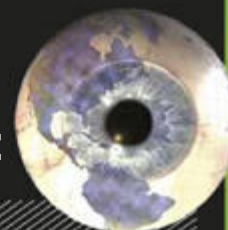
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The Nile is the world's longest river - though its exact source is still debated

PHOTO: THINKSTOCK

THE EARTH



Our planet is unique. Its size (12,756km in diameter at the equator), orbit, temperature and atmosphere have nurtured life. We've compiled the most fascinating facts about our home and its geographical features

THE 10 LONGEST RIVERS

01

Nile

6,695km

East and North Africa



The world's longest river has two main tributaries: the Blue Nile, rising in Ethiopia, and the longer White Nile, emerging from Lake Victoria. Figures for the river's length vary, as the exact source is still debated; 6,650km and 6,695km are often quoted, but an expedition in 2006 claimed to have reached the true source, and subsequent figures have been as high as 6,853km. Whatever its true length, the Nile - which flows through Uganda (and also possibly the Democratic Republic of Congo, Rwanda and Burundi, depending on the accepted source), South Sudan, Sudan, Ethiopia and Egypt on its way to the Mediterranean, is one of the world's mightiest rivers.

02

Amazon

6,516km

South America

This river discharges 200,000m³ of water per second, fed by sources in Bolivia, Colombia, Ecuador, Peru and Brazil.

03

Yangtze

6,380km

China

Chiang Jiang, a Mandarin name for the Yangtze, means literally 'Long River' - it drains about 20% of China's area.

04

Mississippi-Missouri

5,969km

USA

This combined river system drains some 31 US states and two Canadian provinces.

05

Yenisei River

5,539km

Siberia

There's some debate about the true source of the Yenisei, so its place in this list could be lower.

06

Ob-Irtysh

5,410km

Siberia

The Ob River flows through Siberia into the Kara Sea, while its tributary the Irtysh rises in the Altai Mountains.

07

Yellow River

5,464km

China

The basin of the Huang Ho (also known as 'China's Sorrow') was the birthplace of Chinese civilisation.

08

Paraná-Río de la Plata

4,880km

South America

This river's name comes from the Tupi phrase *para rehe onáva*, meaning 'as big as the sea'.

09

Congo River

4,700km

Central Africa

Also known as the Zaire, the Congo is the world's deepest river - depths of 230m have been measured.

10

Amur-Argun

4,440km

North Asia

The Amur flows 2,824km along the Russia-China border, and is fed by the Argun rising in Inner Mongolia.



The official height of Everest (8,848m) includes 4m of snow - its rock height is 8,844m

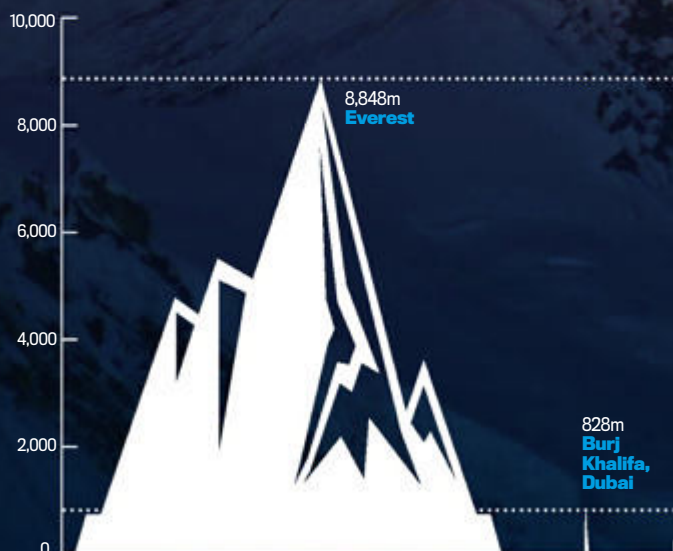
THE 10 HIGHEST MOUNTAINS

Highest on Earth (and in Asia)



Everest
8,848m
Nepal/China

Called Sagarmatha in Nepal and Chomolungma in Tibet, this mountain was named simply Peak XV by the 1856 Great Trigonometric Survey of India that established that it was the world's highest.



Highest in Europe

Elbrus
5,642m
Russia

Highest in North America

McKinley (Denali)
6,194m
Alaska, USA

Highest in South America

Aconcagua
6,961m
Argentina

Highest in Australasia

Puncak Jaya
4,884m
Papua, Indonesia

Highest in Africa

Kilimanjaro
5,895m
Tanzania

Highest in Antarctica

Vinson
4,892m
Ellsworth Mountains

Tallest from base to tip

Mauna Kea
10,058m
Hawai'i Island, Hawaii
Most of this mountain is underwater - only 4,205m is above sea level.

Highest from near the Equator

Chimborazo
6,268m
Ecuador
The Earth bulges at its middle, so this mountain's peak (almost on the equator) is actually nearer to the Moon than Everest is.

Highest on Mars

Olympus Mons
21.9km

THE 10 LOWEST POINTS ON LAND

Elbrus is a dormant volcano in the western Caucasus



Kilimanjaro consists of three volcanic cones; the highest is Kibo or Uhuru Peak



01 **Dead Sea,**
414m below sea level
Israel/Palestine/Jordan



02 **Lake Assal**
155m below sea level
Djibouti

03 **Turpan Pendi**
154m below sea level
China

04 **Qattara Depression**
133m below sea level
Egypt

05 **Vpadina Kaundy**
132m below sea level
Kazakhstan

06 **Danakil**
125m below sea level
Ethiopia



07 **Laguna del Carbon**
105m below sea level
Argentina

08 **Death Valley,**
86m below sea level
California, USA

09 **Vpadina Akchanaya**
81m below sea level
Turkmenistan

10 **Salton Sea**
69m below sea level
California, USA



THE 10 TALLEST WATERFALLS

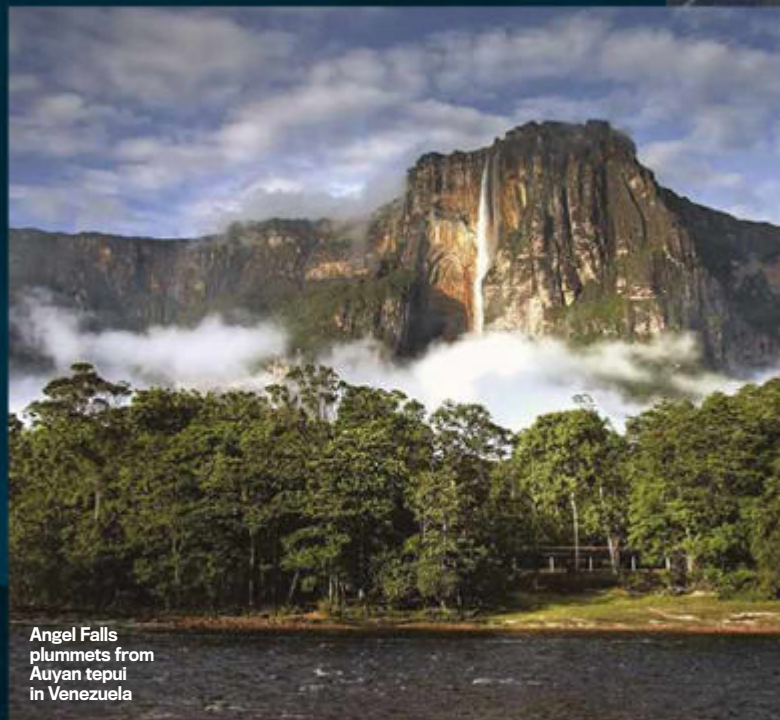
01

Angel Falls 979m Venezuela



The world's highest uninterrupted waterfall cascades from the top of the *tepui* (flat-topped mountain) called Auyan, with a single plunge of 807m. Called *Kerepakupai Vená* ('waterfall of the deepest place') in the local Pemon language, its English-language name

was bestowed in honour of Jimmie Angel, the American aviator who was the first to fly over it in 1933.



Angel Falls plummets from Auyan tepui in Venezuela

06

James Bruce Falls 840m Canada

05

Skorga 864m Norway

04

Vinnufallet 865m Norway

08

Kjerrskredfossen 830m Norway

09

Waihilau Falls 792m Hawaii, USA

10

Colonial Creek Falls 783m Washington State, USA

03

Three Sisters Falls 914m Peru

02

Tugela Falls 948m South Africa

07

Browne Falls 836m New Zealand

Browne Falls in the majestic
Doubtful Sound on New
Zealand's South Island

THE 10 LARGEST LAKES

01 **Caspian Sea**
371,000km²
Central Asia

02 **Lake Superior**
82,100km²
USA/Canada

03 **Lake Victoria**
68,800km²
East Africa

04 **Lake Huron**
59,600km²
USA/Canada

05 **Lake Michigan**
57,800km²
USA

06 **Lake Tanganyika**
32,900km²
East Africa

07 **Lake Baikal**
31,722km²
Russia

08 **Great Bear Lake**
31,328km²
Canada

09 **Lake Malawi (Nyasa)**
30,044km²
Malawi/Tanzania/
Mozambique

10 **Great Slave Lake**
28,568km²
Canada

Water cascades into
the mist at Tugela
Falls in South Africa



Powerful katabatic winds drive blizzards across Antarctica, though it rarely snows

THE 10 LARGEST DESERTS

01

Antarctic Desert 13,829,430km²



Though it's largely covered with a thick coat of ice, Antarctica is actually extremely dry. Inner regions receive less than 50mm of precipitation each year - less than the Sahara - and some dry valleys experience virtually none at all.

02

Arctic
13,726,936km²

03

Sahara
9,400,000km²
North Africa

04

Arabian Desert
2,330,000km²
Arabian Peninsula

05

Gobi Desert
1,300,000km²
China/Mongolia

06

Kalahari Desert
900,000km²
Angola/
Botswana/
Namibia/
South Africa

07

Patagonian Desert
670,000km²
Argentina/Chile

08


Great Victoria Desert
647,000km²
Australia

09

Syrian Desert
520,000km²
Iraq/Jordan/
Syria

10

Great Basin Desert
492,000km²
USA



Though popular images of the Sahara depict endless rolling dunes, much of it - as here, in Algeria - can be rocky



Some areas of Chile's Atacama Desert receive just 1mm of rain each year

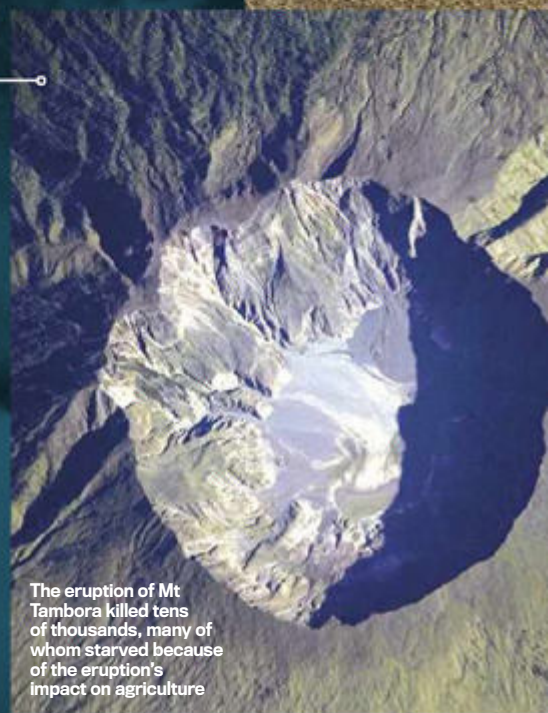
400

years - the length of time some areas of Chile's Atacama Desert went without rain between 1570 and 1970



THE 10 DEADLIEST VOLCANIC ERUPTIONS

- 01 **Tambora**
Indonesia
Erupted: 1815
Estimated deaths: 71,000
- 02 **Krakatoa**
Indonesia
Erupted: 1883
Deaths: 36,417
- 03 **Mount Pelée**
Martinique
Erupted: 1902
Deaths: 29,025
- 04 **Nevado del Ruiz**
Colombia
Erupted: 1985
Deaths: 25,000
- 05 **Unzen**
Japan
Erupted: 1792
Deaths: 15,000
- 06 **Laki**
Iceland
Erupted: 1783
Deaths: 9,350
- 07 **Santa María**
Guatemala
Erupted: 1902
Deaths: 6,000
- 08 **Kelut**
Indonesia
Erupted: 1919
Deaths: 5,110
- 09 **Galunggung**
Indonesia
Erupted: 1882
Deaths: 4,011
- 10 **Vesuvius**
Italy
Erupted: AD 79
Deaths: upwards of 3,000



The eruption of Mt Tambora killed tens of thousands, many of whom starved because of the eruption's impact on agriculture

THE 10 COLDEST PLACES



- 01 **Ridge near Dome Fuji**
Antarctica
-93.2°C
Recorded in August 2010 from a remote sensing satellite.

- 02 **Vostok Station**
Antarctica
-89.2°C
The lowest ground-monitored temperature, recorded on 21 July 1983 at a Russian Antarctic research station.

- 03 **Dome Argus**
Antarctica
-82.5°C



- 03 **Amundsen-Scott South Pole Station**
Antarctica
-82.5°C

THE 10 HOTTEST PLACES

01 Dasht-e Lut

Iran
70.7°C

The highest surface temperature officially confirmed on Earth was detected by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite at Gandom Beryan in the Dasht-e Lut (Lut Desert) between 2003 and 2005.

A salt river winds through the scorching desert at Dasht-e Lut

02 Queensland Outback

Australia
69.2°C

03 Flaming Mountains

Xinjiang, China
66.7°C

04 Al-Aziziyah

Libya
57.8°C

For many years, this temperature (detected in September 1922) was the highest ever recorded.

05 Death Valley

USA
56.7°C

Death Valley, in California's Mojave Desert, is the USA's lowest, driest and hottest place

06 Rub' al Khali (Empty Quarter)

Arabian Peninsula
56°C

07 Kebili

Tunisia
55°C

08 Timbuktu

Mali
54°C

09 Tirat Zvi

Israel
53.7°C

This temperature was recorded at a kibbutz in June 1942 - at that time, the highest ever documented in Asia.

10 Dallol

Ethiopia
34.4°C

This was the average annual temperature from 1960 to 1966.

05

Oymyakon

Russia
-71.2°C

The lowest air temperature recorded in the northern hemisphere was detected at this Russian village in 1926.

06

Klinck research station

Greenland
-69.4°C

07

North Ice

Greenland
-66°C

This low was recorded at this British North Greenland Expedition research station in 1954.

08

Snag

Yukon, Canada
-63°C

09

Denali

Alaska, USA
-59.7°C

10

Verkhoyansk

Russia
-45.4°C

About 80% of the surface of Greenland is covered by a vast ice sheet

THE 10 LARGEST ISLANDS

01

Greenland
2,175,600km²

Convention dictates that continents are not considered islands - otherwise Australia, at 7,692,024km², would top Greenland by a factor of more than three. Though the world's largest island, Greenland is sparsely populated, with fewer than 60,000 inhabitants; around 80% of its surface is covered by a vast ice sheet.



02

New Guinea
785,753km²

03

Borneo
748,168km²

04

Madagascar
587,713km²

05

Baffin Island, Canada
503,944km²

06

Sumatra, Indonesia
443,066km²

07

Honshu, Japan
225,800km²

08

Victoria Island, Canada
220,548km²

09

Great Britain
209,331km²

10

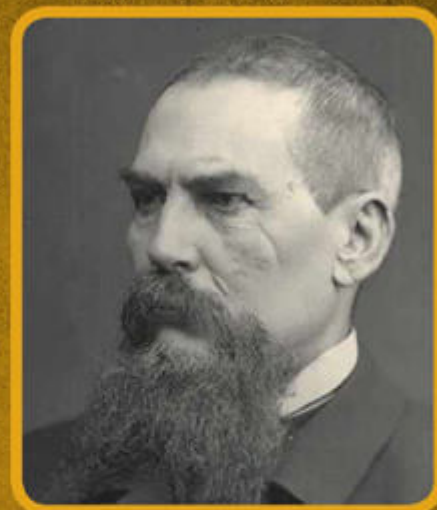
Ellesmere Island, Canada
196,236km²

10 Famous British Explorers

Sir Richard Francis Burton
1821-90

i Travelled the Hajj to Mecca, first European to see Lake Tanganyika

The polymath soldier, fencer, orientalist, linguist and spy reputedly spoke 29 languages, explored East Africa's Great Lakes and was one of only a handful of Europeans to travel to the holy shrine at Mecca. He also translated the *Kama Sutra* and *One Thousand And One Nights*.



David Livingstone
1813-73

i Traced the mighty Zambezi, first European to see Victoria Falls

The Scottish missionary searched (unsuccessfully) for the source of the Nile, traced the Zambezi to the Indian Ocean and became the first European to see Lake Malawi and Victoria Falls.

Gertrude Bell
1868-1926

i Explored and mapped out the Middle East

Political officer, mountaineer, archaeologist and spy, Bell explored, mapped and photographed Syria and other parts of the Middle East in detail. She was instrumental in the foundation of the states of Jordan and Iraq.

William Dampier
1651-1715

i Mapped the coastline of Australia

When marooned off Western Australia in 1688, Dampier made comprehensive notes about the country's flora, fauna and people, returning in 1699 to map the north-western coastline. He also circumnavigated the globe three times.

James Cook
1728-79

i Charted Pacific, Australia and New Zealand

The son of a farm worker, Cook worked his way up through the ranks in the navy. After mapping stretches of the Canadian coast, Cook undertook three exploratory voyages, mapping Australia's east coast and circumnavigating New Zealand.

Ernest Shackleton
1874-1922

i Made heroic efforts to explore Antarctica

Shackleton served in Scott's Discovery expedition to Antarctica and made his own attempt to reach the South Pole in 1908-9, but is best known for his heroic open-boat journey and foot crossing of South Georgia after his ship, the *Endurance*, sank.

Sir Walter Raleigh
c1554-1618

i Explored the New World, including Virginia and the Orinoco River

Raleigh's initial efforts to colonise Virginia ended in failure, but paved the way for successful colonisation. He later explored the Orinoco River and popularised tobacco smoking in Britain.

Sir Francis Younghusband
1863-1942

i Explored Central, South and East Asia, notably Tibet

Known for his pivotal role in the 'Great Game' - the jockeying for supremacy in Central Asia between Russia and Britain - Younghusband explored much of Asia, notably, in 1903-4, long-isolated Tibet.

Hugh Clapperton
1788-1827

i Explored West and Central Africa, first European to see Lake Chad

Less well known than the later Victorian explorers, Clapperton was among the first Europeans to explore the empires and Hausa states of what is now Nigeria in West Africa.

Henry Hudson
c1565-?1611

i Made early searches for North-West Passage, explored Hudson River

Commissioned by English merchants to find a western route to China, Hudson made two expeditions to North America, mapping the areas around modern-day New York City and Hudson Bay in Canada.

DID YOU KNOW?

The spacesuit worn by Neil Armstrong for the 1969 Moon landing was made by a bra manufacturer

First primate in space

Albert II

14 June 1949
A rhesus monkey called Albert II reached an altitude of about 134km in a US-launched V2 rocket. Albert II died on impact after a parachute failure.

First animal in orbit

Laika

3 November 1957
The Russian mongrel dog Laika survived four orbits aboard *Sputnik 2* before dying, possibly as a result of overheating.

First manually controlled spaceflight

Alan Shepard

5 May 1961
The American reached an altitude of 187km aboard *Freedom 7* during which he had some control of his craft (Gagarin's flight was strictly automatic).

First whole day in orbit

Gherman Titov

6 August 1961
As well as spending a whole day aboard *Vostok 2*, Russian Titov orbited the Earth 17 times and was the first to sleep in space.

SPACE



Whether it's comparing the sizes of planets, the length of exploratory space missions or the raw power of rockets, here we tot up the vast numbers that govern what lies beyond our planet

10 SPACE FIRSTS

First man in orbit

Yuri Gagarin

Launch date: 12 April 1961

The Russian cosmonaut completed an orbit of Earth during his 108-minute spaceflight aboard *Vostok 1*. Being the first human in space, he later explained the experience of weightlessness: "You feel as if you were hanging in a horizontal position in straps. You feel as if you are suspended." After landing back on Earth, Gagarin became an instant celebrity, touring the world to tell the adoring public about his big adventure. It was to be his only mission into space and he died in a plane crash in 1968 during a routine flight. His ashes are buried in the walls of the Kremlin in Moscow.



First woman in orbit

Valentina Tereshkova

16 June 1963
The Russian orbited the Earth 48 times during her near-three-day spell aboard *Vostok 6*.

First space walk

Alexey Leonov

18 March 1965
Another Russian cosmonaut, Leonov undertook a 12-minute period of 'extra-vehicular activity' (space walk) during the *Voskhod 2* mission. He was secured by a five-metre tether.

First death in space

Vladimir Komarov

24 April 1967
The Russian was killed when the *Soyuz 1* spacecraft he was piloting crashed on its re-entry to Earth.

First moon walk

Neil Armstrong

21 July 1969
Apollo 11 mission commander Armstrong climbed down from the lunar lander Eagle and onto the Moon's surface.

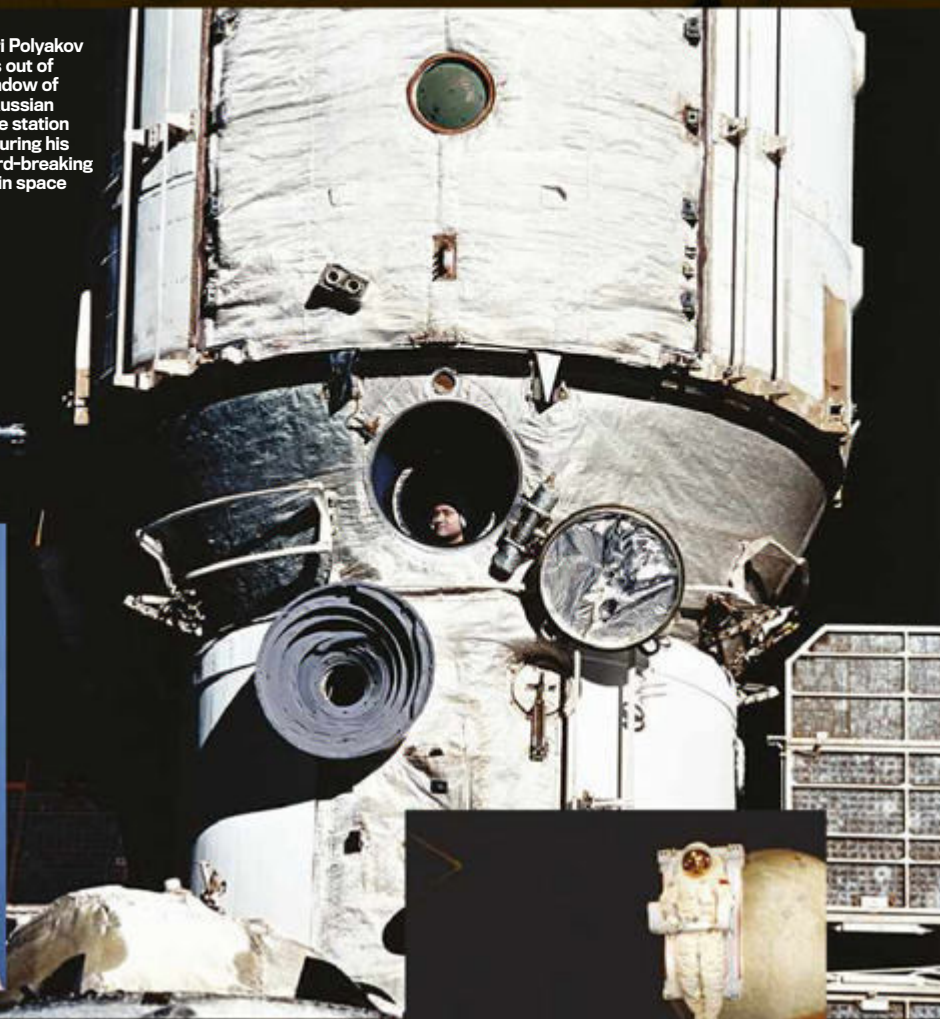
First space tourist

Dennis Tito

28 April 2001
The American multimillionaire spent nearly eight days in space, reaching the International Space Station EP-1 aboard the Russian craft *Soyuz TM-32*.

THE 10 LONGEST HUMAN SPACE FLIGHTS

Valeri Polyakov looks out of a window of the Russian space station *Mir* during his record-breaking time in space



01

Valeri Polyakov
Russia

Mission:
Mir Space Station
Duration:
437 days
8 January 1994–
22 March 1995

02

Sergei Avdeyev
Soviet Union

Mission:
Mir Space Station
Duration:
379 days
13 August 1988–
28 August 1989

03

Vladimir Titov & Musa Manarov
Soviet Union

Mission:
Mir Space Station
Duration:
365 days
21 December 1987–
21 December 1988

04

Yuri Romanenko
Soviet Union

Mission:
Mir Space Station
Duration:
326 days
6 February 1987–
29 December 1987



05

Sergei Krikalev
Soviet Union/
Russia

Mission:
Mir Space Station
Duration: 312 days
19 May 1991–
25 March 1992

06

Valeri Polyakov
Soviet Union

Mission:
Mir Space Station
Duration:
240 days
29 August 1988–
7 April 1989

07

Leonid Kizim, Vladimir Solovyov & Oleg Atkov
Soviet Union

Mission:
Salyut 7 Space Station
Duration:
237 days
8 February 1984–
2 October 1984

08

Mikhail Tyurin & Michael López-Allegria
Russia & USA

Mission:
International Space Station
Duration:
215 days
18 September 2006–
21 April 2007

09

Anatoli Berezovoy & Valentin Lebedev
Soviet Union

Mission:
Salyut 7 Space Station
Duration:
211 days
13 May 1982–
10 December 1982

10

Nikolai Budarin & Talgat Musabayev
Russia

Mission:
Mir Space Station
Duration:
207 days
29 January 1998–
25 August 1998

THE 10 BIGGEST MOONS IN OUR SOLAR SYSTEM



The largest moon in our Solar System is Ganymede, a satellite of Jupiter

01

Ganymede
Radius:
2,631km
Satellite of:
Jupiter

02

Titan
Radius:
2,576km
Satellite of:
Saturn

03

Callisto
Radius:
2,410km
Satellite of:
Jupiter

04

Io
Radius:
1,821km
Satellite of:
Jupiter

05

Moon
Radius:
1,737km
Satellite of:
Earth

06

Europa
Radius:
1,561km
Satellite of:
Jupiter

07

Triton
Radius:
1,353km
Satellite of:
Neptune

08

Titania
Radius:
788km
Satellite of:
Uranus

09

Rhea
Radius:
764km
Satellite of:
Saturn

10

Oberon
Radius:
761km
Satellite of:
Uranus

27.3

The length in Earth days that the Moon takes to complete its orbit of our planet



Ganymede



Titan



Callisto



Io



Moon



Europa



Triton



Titania



Rhea



Oberon

10 IMMENSE THINGS IN SPACE

01 Biggest asteroid

Ceres

950km diameter (average)

Discovered in 1801, Ceres makes up a third of the total mass of the asteroid belt between Mars and Jupiter.

02 Biggest object in our solar system

Sun

1,392,000km diameter

The yellow dwarf star around which we orbit comprises over 99.8 per cent of the total mass of our solar system.

03 Biggest known planet

GQ Lup b

30 times the radius of Jupiter

This huge exoplanet, detected orbiting a star some 457 light-years from Earth, may have a mass up to 36 times that of Jupiter and is fiercely hot - possibly 2,650 kelvin.

04 Largest structure in the universe

Huge Large Quasar Group (Huge-LQG)

4 billion light-years across

In 2013, an international team detected a chain of some 73 quasars stretching so far that its existence challenges the fundamental Cosmological Principle.

05 Biggest black hole

Centre of NGC 1277

17 billion solar mass

This supermassive black hole, at the centre of the NGC 1277 galaxy 220 million light-years away, has a mass 17 billion times greater than our Sun - itself about two nonillion kg.

06 Largest galaxy

IC 1101

Six million light-years across

This supergiant elliptical galaxy, discovered in 1790 by William Herschel, at the centre of the Abell 2029 cluster is about one billion light-years away. Our own galaxy, the Milky Way, is a mere 100,000 light-years across.

07 Biggest water cloud

Around quasar APM 08279+5255

40 billion times the mass of Earth

In 2011, researchers discovered a vast cloud of water vapour surrounding a quasar some 12 billion light-years away. The cloud holds enough water to fill the Earth's oceans 140 trillion times over.

08 Biggest comet

McNaught

Visible tail 35°

The spacecraft *Ulysses* passed through the tail of this comet in 2007 and detected ionised gas at a distance of 225 million km behind the nucleus. The 'shocked wind' behind the comet was larger still, making McNaught reportedly the largest comet ever discovered.

09 Biggest nothing

Boötes Void

250 million light-years across

An area of space containing nearly no objects (though a few galaxies are present), this 'void' is around 700 million light-years from Earth.

10 Biggest star

Westerlund 1-26

1,530 solar radii

Measuring distant stars is tricky - determining the edge of the star can be made difficult by solar winds - but the Royal Astronomical Society believes this red supergiant, which is about 1,000,000,000km across and some 16,000 light-years from Earth, is the largest.



THE 10 BRIGHTEST STARS IN THE UNIVERSE

01 Sirius
Constellation: Canis Major
Distance from Earth:
 8.60 light-years
Apparent magnitude: -1.44
Absolute magnitude: 1.45

05 Vega
Constellation: Lyra
Distance: 25.04 light-years
Apparent magnitude: 0.03
Absolute magnitude: 0.60

06 Capella
Constellation: Auriga
Distance: 42.80 light-years
Apparent magnitude: 0.08
Absolute magnitude: -0.51

07 Rigel
Constellation: Orion
Distance: 863 light-years
Apparent magnitude: 0.18
Absolute magnitude: -6.93

08 Procyon
Constellation: Canis Minor
Distance: 11.46 light-years
Apparent magnitude: 0.40
Absolute magnitude: 2.67

09 Betelgeuse
Constellation: Orion
Distance: 498 light-years
Apparent magnitude: 0.45
Absolute magnitude: -5.47

10 Achernar
Constellation: Eridanus
Distance: 139 light-years
Apparent magnitude: 0.45
Absolute magnitude: -2.70

02 Canopus
Constellation: Carina
Distance: 309 light-years
Apparent magnitude: -0.62
Absolute magnitude: -5.50

03 Alpha Centauri
Constellation: Centaurus
Distance: 4.32 light-years
Apparent magnitude: -0.28
Absolute magnitude: 4.11

04 Arcturus
Constellation: Boötes
Distance: 36.72 light-years
Apparent magnitude: -0.05
Absolute magnitude: -0.35

DID YOU KNOW?

The surface area of the Sun is nearly 12,000 times the surface area of Earth

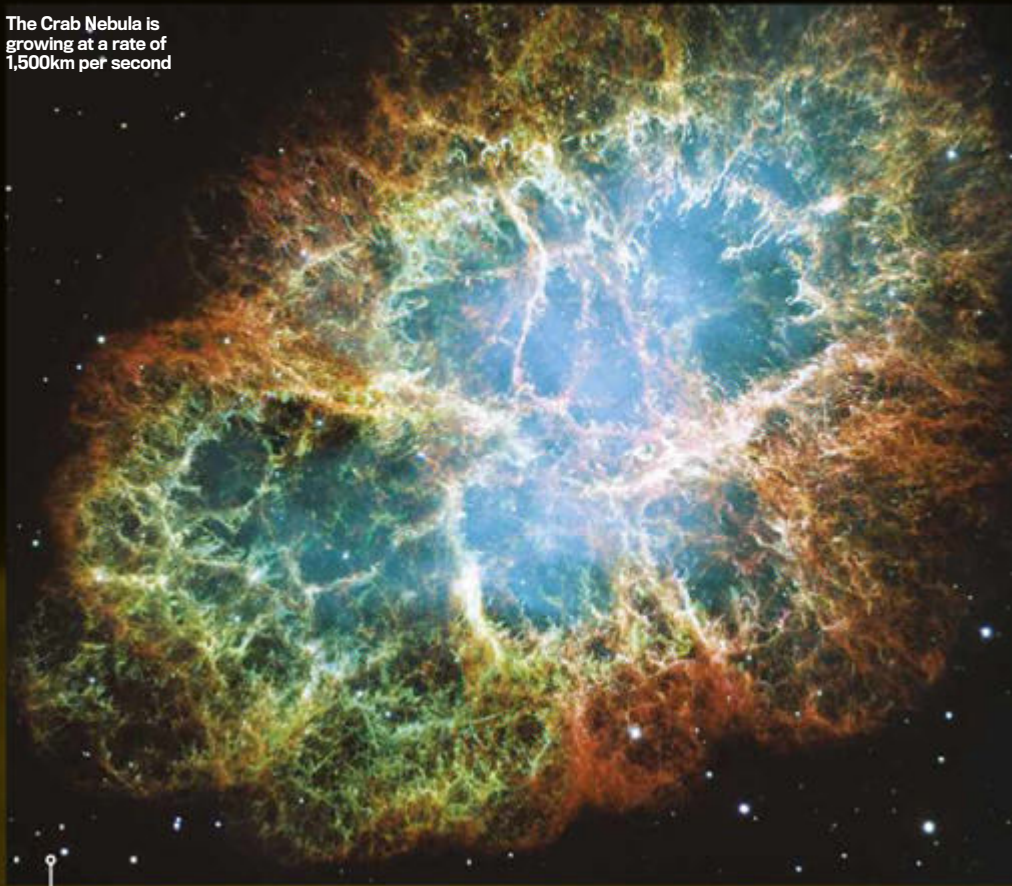


10 OF PATRICK MOORE'S FAVOURITE THINGS

01 The Crab Nebula

It is not so spectacular as a total solar eclipse, nor as lovely as Saturn, but its importance to astronomers cannot be overestimated. The Crab Nebula shows up faintly in the sky. It is 6,300 light-years away. Its present diameter is 11 light-years, but it is expanding at a rate of over 1,500km/s.

The Crab Nebula is growing at a rate of 1,500km per second



02 The rings of Saturn

Discovered in 1610 by Galileo, Saturn's rings were once thought to be solid or liquid sheets, but actually they are made up of pieces of water ice, moving round Saturn in the manner of dwarf moons. Though the entire ring system has a diameter of 272,000km, they are amazingly thin; no more than a kilometre at most.

03 Total eclipse of the Sun

There can be nothing in all nature to match the glory of a total solar eclipse – and we are on the only planet in the Galaxy able to see them. As the last segment of the Sun is covered by the onrushing Moon, the sky darkens, planets and bright stars come out and the pearly corona flashes into view, sometimes accompanied by brilliant red prominences.

04 Methane rain

Titan has a dense atmosphere and is composed mainly of nitrogen together with methane, but the existence of lakes or seas on its surface was uncertain. Now the Cassini orbiter has sent back radar images showing features which can hardly be anything other than lakes of methane – and that methane rain falls on the surface.

THE 10 BIGGEST ASTEROID IMPACTS ON EARTH

01

Vredefort Crater

When: Around two billion years ago
Where: Free State, South Africa

An asteroid up to 10km across created a huge crater with a diameter of 300km.

02

Chicxulub Crater

When: Around 65 million years ago
Where: Yucatán, Mexico

A meteorite with a diameter of 10km blasted a crater 180km wide and 20km deep.

03

Sudbury Basin

When: Around 1.8 billion years ago
Where: Ontario, Canada

The current 62km-long crater is the eroded remains of an astrobleme of 250km around.

04

Manicouagan Crater

When: Around 215 million years ago
Where: Quebec, Canada

A 5km-wide asteroid created this 100km-diameter crater that now contains a lake and island.

05 The ice fountains of Enceladus

Enceladus, one of Saturn's icy satellites, is just over 1,000km in diameter. This planet is active; the Cassini orbiter has imaged fountains of icy particles rising from vents in the south polar region. This may indicate the presence of water not far below the surface.

06 Supervolcano

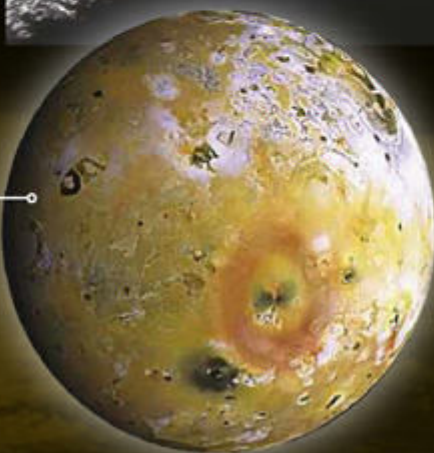
Pele is perhaps the most spectacular of the volcanoes on Jupiter's satellite Io. The red heart-shaped ring was produced by the sulphur fallout from Pele's plume; it is over 1,300km in diameter. The lava from Pele is very hot indeed, and temperatures of over 1000°C have been measured. Scientists believe that the Pele volcano's caldera is filled with liquid lava topped by a floating crust.

07 Solar blow-out

A coronal mass ejection is a huge disturbance in the Sun, resulting in the ejection of solar material from the corona, mainly in the form of ionised gas. The average ejection speed is over 480km/s. Once it reaches Earth, the ejecta compress our magnetosphere and can disrupt radio communications.

08 The Moon's 'eastern' sea

I found this 900km-diameter lunar impact feature in 1948 and referred to it as the 'eastern' sea, but in 1961 the International Astronomical Union (IAU) reversed lunar east and west, so it is now actually a western mare. A 'mare' isn't a liquid sea, it's a dark, smooth region on the Moon.



09 The star of stars

Eta Carinae is the most spectacular 'variable' star in the sky - meaning its brightness waxes and wanes over time. Eta Carinae is unstable and eventually it will explode as a supernova or hypernova (an exceptionally violent supernova). When it does, the event is bound to be spectacular, even from our range of over 7000 light-years.

10 Super star cluster

Omega Centauri is the brightest of the spherical collections of stars known as globular clusters that orbit our Galaxy. It lies 17,000 light-years away and is an easy object to see with the naked eye and a splendid sight with binoculars or a telescope. It contains a huge number of stars - perhaps as many as 10 million.

05

Popigai Crater

When: Around 35.7 million years ago
Where: Siberia, Russia
The asteroid that created this 100km diameter was between 5km and 8km across.

06

Acraman Crater

When: Around 580 million years ago
Where: South Australia
Now heavily eroded, this crater may originally have had a diameter of 90km.

07

Chesapeake Bay Crater

When: Around 35 million years ago
Where: Virginia, USA
The bolide impact gouged an inner deep crater 38km across and a 85km-wide outer crater.

08

Kara Crater

When: Around 70.3 million years ago
Where: Nenetsia, Russia
Another heavily eroded crater, this is now 65km in diameter but may have been as large as 120km across.

09

Woodleigh Crater

When: Around 364 million years ago
Where: Western Australia
This ancient crater is not exposed to the surface, but may be as big as 120km in diameter.

10

Morokweng Crater

When: Around 145 million years ago
Where: Kalahari Desert, South Africa
Another buried site, this 70km-diameter crater was discovered in 1994.

10 OF THE MOST POWERFUL ROCKETS

It first flew nearly half a century ago, but *Saturn V* remains the beefiest rocket of them all

01

Saturn V
USA
Manufacturer: Boeing, North American and Douglas
First flight: 1967
Height: 110.6m
Thrust: 34.02MN

02

Energia
USSR
Manufacturer: RSC Energia
First flight: 1987
Height: 58.7m
Thrust: 29MN

03

Titan IV
USA
Manufacturer: Lockheed Martin
First flight: 1989
Height: 44m
Thrust: 15.2MN

04

Space Shuttle
USA
Manufacturer: Various, including Boeing and Lockheed Martin
First flight: 1981
Height: 56.1m
Thrust: 12.5MN

05

Proton
USSR
Manufacturer: Khrunichev
First flight: 1965
Height: 53m
Thrust: 10.5MN

06

H-II/B
Japan
Manufacturer: Mitsubishi
First flight: 2009
Height: 56.6m
Thrust: 9.2MN

07

Zenit
USSR
Manufacturer: Yuzhnoye Design Bureau
First flight: 1985
Height: 57m
Thrust: 8.1MN

08

Saturn IB
USA
Manufacturer: Chrysler and Douglas
First flight: 1966
Height: 43.2m
Thrust: 7.1MN

09

Saturn I
USA
Manufacturer: Chrysler and Douglas
First flight: 1961
Height: 55m
Thrust: 6.7MN

10

Ariane 5
Europe
Manufacturer: Arianespace, Astrium for ESA
First flight: 1996
Height: 52m
Thrust: 6.5MN

DID YOU KNOW?

The V-2, the first rocket to enter space, was neither American nor Russian. It was a German invention

THE 10 BIGGEST EXOPLANETS IN THE UNIVERSE

01

GQ Lup b

Radius*: 33.6 (average)

Discovered: 2004

Distance from Earth:
457 light-years

02

CT Cha

Radius*: 24.66

Discovered: 2007

Distance from Earth:
538 light-years

03

WASP-79

Radius*: 23.43 (average)

Discovered: 2012

Distance from Earth:
783 light-years

04

KOI-13

Radius*: 20.5

Discovered: 2011

Distance from Earth:
1,970 light-years

05

TrES-4

Radius*: 20.165 (average)

Discovered: 2007

Distance from Earth:
1,430 light-years

06

WASP-12

Radius*: 20.1 (average)

Discovered: 2008

Distance from Earth:
800 light-years

07

HAT-P-32

Radius*: 2.053 (average)

Discovered: 2011

Distance from Earth:
1,044 light-years

08

WASP-17

Radius*: 19.5

Discovered: 2009

Distance from Earth:
1,000 light-years

09

HAT-P-40

Radius*: 19.392 (average)

Discovered: 2012

Distance from Earth:
1,367 light-years

10

WASP-78

Radius*: 19.055

Discovered: 2012

Distance from Earth:
1,793 light-years

* Radius = multiples of Earth's radius

TOP 10 DISTANCES COVERED BY SPACE PROBES

01
Voyager 1
Launched: 1977
Distance travelled: 19 billion km
Reached: Jupiter, Saturn

02
Pioneer 11
Launched: 1973
Distance travelled: 16 billion km
Reached: Jupiter, Saturn

03
Voyager 2
Launched: 1977
Distance travelled: 15.6 billion km
Reached: Jupiter, Saturn, Uranus, Neptune

04
Pioneer 10
Launched: 1972
Distance travelled: 12 billion km
Reached: Jupiter

05
Galileo
Launched: 1989
Distance travelled: 4.6 billion km
Reached: Venus, Ida, Jupiter

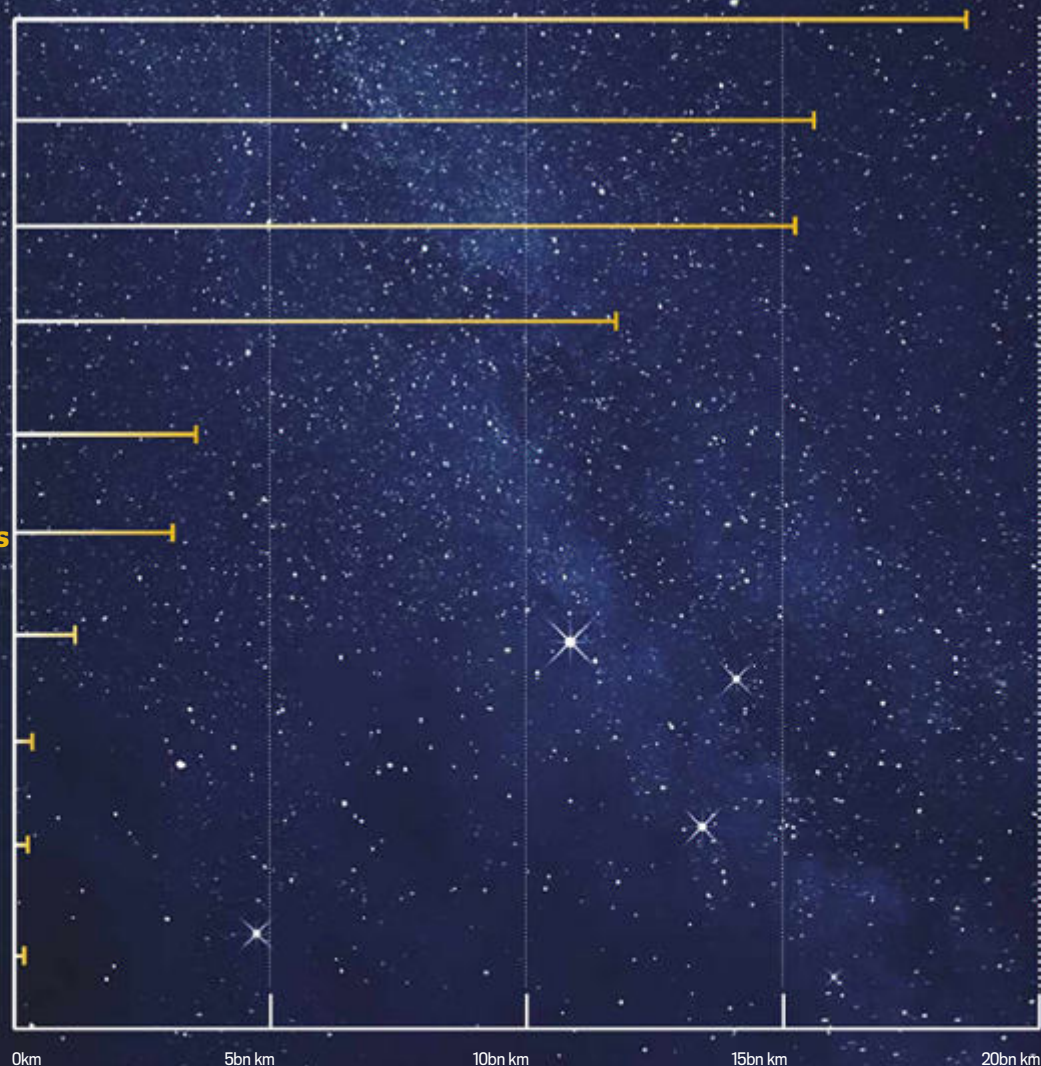
06
Cassini-Huygens
Launched: 1997
Distance travelled: 3.5 billion km
Reached: Venus, Jupiter, Saturn, Iapetus, Titan

07
Magellan
Launched: 1989
Distance travelled: 1.3 billion km
Reached: Venus

08
Viking 1 and 2
Launched: 1975
Distance travelled: 400 million km
Reached: Mars

09
Mars Express
Launched: 2003
Distance travelled: 400 million km
Reached: Mars

10
Venera 9
Launched: 1975
Distance travelled: 360 million km
Reached: Venus



10 Famous Astronomers

Nicolaus Copernicus
1473-1543

i Proposed a heliocentric model for the universe

Since the days of Aristotle, the accepted model of the solar system had the Earth stationary at its centre, with the Sun and planets revolving around it. The Polish astronomer's revolutionary heliocentric model - with the Sun as the stationary force - challenged this view.



Galileo Galilei
1564-1642

i Supported heliocentrism, discovered Jupiter's moons and developed telescopes

Galileo's support of the Copernican heliocentric model saw his ideas investigated by the Roman Inquisition of 1615. But the Italian's own achievements were formidable, including developing telescopes enabling good views of the Milky Way and Jupiter's moons.

Johannes Kepler
1571-1630

i Improved the refracting telescope and developed the laws of planetary motion

Kepler's laws described how planets moved around the sun, challenging the geocentric models of Aristotle and Ptolemy. The German was a huge influence on Sir Isaac Newton.

Edwin Hubble
1889-1953

i Discovered Hubble's Law, suggesting that the Universe is expanding

Hubble's Law states that the recessional velocity of a galaxy increases with its distance from the Earth. The American was a major champion of the idea of the existence of galaxies beyond the Milky Way.

Eratosthenes
276-194BC

i Measured the circumference of the Earth

Eratosthenes - born in Cyrene, now in Libya - used the angle of the noonday Sun at different places in Egypt to estimate the circumference of Earth. His figure was remarkably accurate - in fact, according to some commentators, he was out by less than 2%.

Charles Messier
1730-1817

i Composed a database of celestial objects

This French astronomer was the first to compile a systematic catalogue of nebulae and star clusters that is still used in the classification of many celestial objects.

George Gamow
1904-68

i Early advocate of the big bang theory

Born in Odessa (in modern-day Ukraine), Gamow was one of the foremost advocates of the theory that the universe was formed in a colossal explosion billions of years ago.

William Herschel
1738-1822

i Discovered Uranus and its moons

Born in Germany Herschel moved to England as a teenager. He became famous for discovering Uranus and two of its major moons, Titania and Oberon, as well as two of Saturn's moons. He also discovered infrared radiation.

Annie Jump Cannon
1863-1941

i Co-created the Harvard Classification Scheme

This American astronomer's classification scheme organised and ordered stars based on their temperatures. Her catalogue listed some 230,000 stars.

Claudius Ptolemy
c 90-c 168

i Writings dominated astronomy for 12 centuries

The *Almagest* produced by this Greco-Roman astronomer and geographer was a celestial almanac that, though based on an erroneous geocentric model, became established as the definitive reference work for some 12 centuries.



Human bone principally consists of collagen and calcium phosphate

DID YOU KNOW?

While the human brain makes up only 2% of total body weight, it uses up between 20-25% of the body's energy

CLIMBING DOWN FROM THE TREES

Discovery: Tree-climbing forebears may have moved towards walking upright 4.4 million years ago

A fossil classified as *Ardipithecus ramidus* was found in Ethiopia's Afar Depression in 1994.

Its mix of features sparked debate that it could be a 'missing link' between two lifestyles.

WIELDING STONE TOOLS

Discovery: Our ancestors used stone tools 3.5 million years ago
Fossils of animal bones discovered in Ethiopia in 2010 show cutting marks indicating butchering with stone tools. These date from some three million years or more before modern humans evolved.

WALKING TALL

Discovery: The world's most famous pre-human species walked upright

Excavated in 1974 in the Afar Depression in Ethiopia, 'Lucy' (*Australopithecus afarensis*) lived between 3.85 and 2.95 million years old and was shown to have walked upright - long before brains grew to modern sizes.

HUMAN EVOLUTION



Delving into half a million years of evolution of our species – with our varied shapes, sizes, cultures and languages, provides fascinating food for thought about the nature of human development

10 KEY BREAKTHROUGHS IN HUMAN EVOLUTION

Grasping with two hands

Discovery: The oldest-known hominid may have had opposable thumbs

Orrorin tugenensis, fossils of which were first found in Kenya in 2000, is the oldest described hominid (human-like) species, dating back up to six million years ago. It had opposable thumbs and may have walked upright.

USING YOUR HEAD

Discovery: Fossil skull indicates upright walking

A dig in South Africa in 1924 unearthed a 2.8-million-year-old fossil *Australopithecus africanus*, dubbed the Taung Child. Its skull structure indicated that the spine connected at the bottom of the cranium – suggesting that it walked upright.

HANDY WITH TOOLS

Discovery: Pre-human species, *Homo habilis*, used tools

At the time the first specimens were discovered at Tanzania's Olduvai Gorge in 1963, it was the first hominid associated with stone tools – so the species, dating from between 2.3 and 1.4 million years ago, was dubbed *Homo habilis* (handy man).

PLAYING WITH FIRE

Discovery: Human ancestor in Asia

The discovery in Java in 1891 of the species named *Homo erectus* provided evidence of the earliest human ancestor found outside Africa, living between 1.8 million and 143,000 years ago. It had human-like traits – long legs, short arms and downward-pointing nostrils – and was believed to use fire.

NEANDERTHALS NAMED

Discovery: The first pre-human species identified

The type specimen of *Homo neanderthalensis* was found in Germany's Neander Valley in 1856. It probably lived from about 300,000 to 50,000 years ago – and may (or may not) have overlapped with modern humans in Europe.

CROSS-BREEDING WITH NEANDERTHALS

Discovery: Humans mated with Neanderthals

The Neanderthal Genome Project, founded in 2006, sequenced the entire genome of a 130,000-year-old specimen found in a Siberian cave. DNA analysis suggests that Neanderthals may have interbred with modern humans.

WHAT'S FOR DINNER

Discovery: The last meals of ancient pre-humans

The discovery of fossils of a newly described species, named *Australopithecus sediba*, in South Africa in 2008 included relatively complete individuals at different stages of development. It's hoped that analysing tartar on the teeth of one specimen might reveal what it ate two million years ago.

THE 10 MOST WIDELY SPOKEN LANGUAGES



- 01 **Mandarin Chinese**
Speakers worldwide: 848m
- 02 **Spanish**
Speakers: 406m
- 03 **English**
Speakers: 335m
- 04 **Hindi**
Speakers: 260m
- 05 **Arabic**
Speakers: 223m
- 06 **Portuguese**
Speakers: 202m
- 07 **Bengali**
Speakers: 193m
- 08 **Russian**
Speakers: 162m
- 09 **Japanese**
Speakers: 122m
- 10 **Javanese (Indonesia)**
Speakers: 84.3m

* Source: www.ethnologue.com. Figures are estimates of first-tongue speakers.

10 TALLEST HUMANS

MALE

01

Robert Wadlow
Height: 2.72m
1918-1940
USA

02

John Rogan
Height: 2.68m
1868-1905
USA

03

John F Carroll
Height: 2.63m
1932-69
USA

04

Leonid Stadnyk
Height: 2.57m*
1971-present
Ukraine

05

Sultan Kösen
Height: 2.51m
1982-present
Turkey



Notes: neither Leonid Stadnyk nor Katia Davila Rodrigues have been measured according to Guinness World Record standards. Other historical claims without legitimate recorded measurements excluded.

10 SHORTEST HUMANS

FEMALE

01

Zeng Jinlian
Height: 2.48m
1964-82
China

02

Jane Bunford
Height: 2.41m
1895-1922
UK

03

Katia D'avila Rodrigues
Height: 2.38m
1963-2011
Brazil

04

Yao Defen
Height: 2.34m
1972-2012
China

05

Sandy Allen
Height: 2.33m
1955-2008
USA

01

Lucia Zarate
Height: 50.8cm
1864-90
Mexico

02

Chandra Bahadur Dangi
Height: 54.6cm
1939-present
Nepal

03

Gul Mohammed
Height: 57cm
1957-97
India

04

Pauline Musters
Height: 58cm
1876-1895
Netherlands

05

Jyoti Amge
Height: 58.4cm
1993-present
India

06

Junrey Balawing
Height: 60cm
1993-present
Philippines

=07

Madge Bester
Height: 65cm
Lived: 1963-present
South Africa

=07

István Tóth
Height: 65cm
1963-2011
Hungary

09

Khagendra Thapa Magar
Height: 67cm
1992-present
Nepal

10

Bridgette Jordan
Height: 69cm
1989-present
USA

DID YOU KNOW?

The heaviest man ever was Jon Brower Minnoch who, in 1978, was estimated to weigh more than 635kg



Lucia Zarate was the shortest human to have ever lived



10 LONGEST-LIVING HUMANS

01

Jeanne Calment

Age: 122 years and 164 days
21 February 1875–4 August 1997
France

02

Sarah Knauss

Age: 119 years and 97 days
24 September 1880–
30 December 1999
USA

03

Lucy Hannah

Age: 117 years and 248 days
16 July 1875–21 March 1993
USA

04

Marie-Louise Meilleur

Age: 117 years and 230 days
29 August 1880–16 April 1998
Canada

05

Maria Capovilla

Age: 116 years and 347 days
14 September 1889–
27 August 2006
Ecuador

06

Tane Ikai

Age: 116 years and 175 days
8 January 1879–12 July 1995
Japan

07

Elizabeth Bolden

Age: 116 years and 118 days
15 August 1890–
11 December 2006
USA

08

Besse Cooper

Age: 116 years and 100 days
26 August 1896–4 Dec 2010
USA

09

Jiroemon Kimura

Age: 116 years and 54 days
19 April 1897–12 June 2013
Japan

10

Misao Okawa

Age (at time of press):
115 years and 332 days
5 March 1898–present
Japan

DID YOU KNOW?

Between 2000 and 2050, the proportion of the world's population over 60 will double to 22%



10 FACTS ABOUT BONES



You lose bones as you grow up

Each human is born with 300–350 bones in his or her body. By the time we reach adulthood, that number is only 206 – many bones fuse during development.

Hands and feet are your boniest parts

More than half of your bones are in your hands and feet – 27 in each hand and 26 in each foot.

Your neck is like a giraffe's

Humans have the same number of cervical vertebrae as a giraffe – seven.

Your bones make blood

Bone marrow produces about 2.4 million erythrocytes (red blood cells) per second.

10 INCREDIBLE HUMAN RECORDS



Longest tongue

Englishman Stephen Taylor's tongue measures at 9.8cm (from the tip to the middle of his closed top lip).

Longest time breath held

In 2012, Stig Severinsen of Denmark held his breath underwater for a remarkable 22 minutes.

Longest nose

Mehmet Özyürek of Turkey has the world's longest nose. In 2010, his proboscis measured at 8.8cm from bridge to tip.



Longest swim

In 2007, Slovenian Martin Strel swam the entire length of the Amazon River, covering 5,268 km in just 67 days.

Longest fingernails

In 2009, American Melvin Boothe's fingernails were measured at having a combined length of 9.85m.

Longest tooth extracted

A tooth measuring 3.2cm long was removed from Loo Hui Jing in Singapore in 2009.



Longest legs

Svetlana Pankratova of Russia possesses 132cm-long legs, as measured in 2003.

Largest hands

American Robert Wadlow, the tallest man ever, also holds the record for largest hands - 32.3cm from wrist to fingertip.

Smallest waist

Cathie Jung of the USA has the world's smallest waist. It measures 38.1cm corseted - and just 53.34cm even without a corset.

Longest run

In 2010, Frenchman Serge Girard ran 27,011km around 25 EU countries - the farthest distance run in 365 days.

* Source: Guinness World Records.

Your smallest bone is in your ear

The smallest bone in the body is only about 3mm long - the stapes (or stirrup) in the middle ear.

You have one unconnected bone

The hyoid, a horseshoe-shaped bone at the base of your tongue, is not joined to another bone - the only such solitary bone in your body.

You have strong legs

Your femur (thigh bone) is the longest, strongest and heaviest bone in your body; its length is 26% of your overall height.

Your bones are light

The bones of an adult comprises a relatively small proportion of his or her total weight - about 15% in men, 12% in women.

Your ribs work hard

Your ribcage expands and contracts up to 10 million times each year - every time you breathe.

Your bones are mostly not living

Bone consists largely of a matrix of collagen and hydroxylapatite (bone mineral) crystals. As little as five per cent is made up of living cells.





10 ENDANGERED LANGUAGES

**Patwin****Where:** USA

Native to northern California, by 2011 it was assumed that just one person spoke Patwin as their first language.

**Kaixána****Where:** Brazil

According to reports from 2006, one named individual spoke this language – though he was 78 years old.

**Diahói****Where:** Brazil

Probably fewer than a hundred members of the indigenous people who spoke this language live in southern Amazonas state; a 2006 study estimated that only one actually spoke the Diahói dialect.

**Apiaká****Where:** Brazil

Only a few hundred members of the Apiaká people survive in northern Mato Grosso state; having adopted Portuguese, only one person is now believed to speak the language.

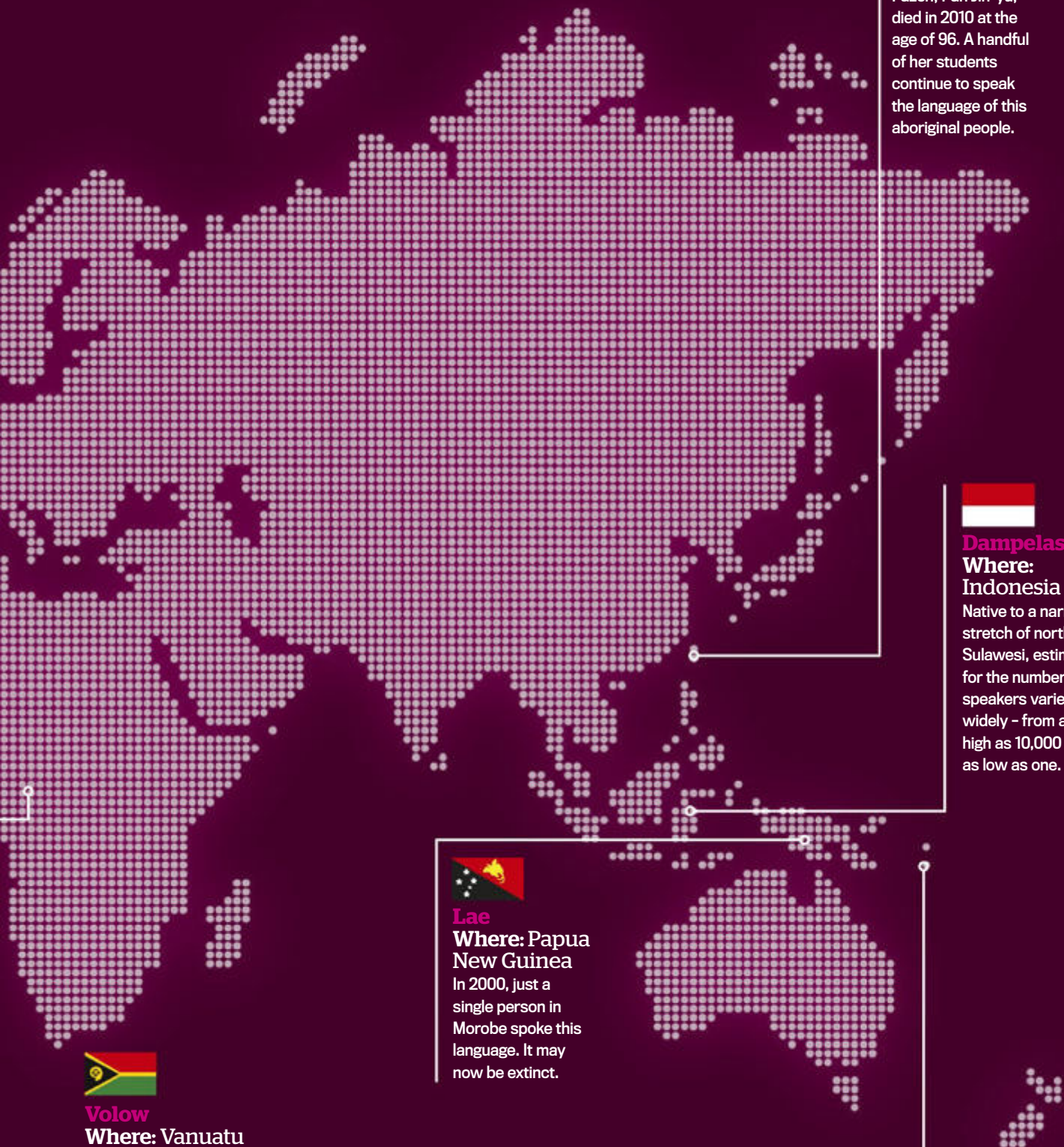
**Chaná****Where:** Argentina/Uruguay

In 2005, a man was discovered who spoke at least some words of this language, long believed extinct.

**Bikya****Where:** Cameroon

In 1986, it was reported that only four people spoke this Bantoid language, only one of them fluently – and he was over 70 years old. Bikya may now be extinct.

* Source: UNESCO Atlas of the World's Languages in Danger, which lists 19 languages as being spoken by no more than one person.

**Pazeh****Where:**
Taiwan

The last truly fluent native speaker of Pazeh, Pan Jin-yu, died in 2010 at the age of 96. A handful of her students continue to speak the language of this aboriginal people.

**Dampelas****Where:**
Indonesia

Native to a narrow stretch of northern Sulawesi, estimates for the number of speakers varies widely - from as high as 10,000 to as low as one.

**Lae****Where:** Papua
New Guinea

In 2000, just a single person in Morobe spoke this language. It may now be extinct.

**Volow****Where:** Vanuatu

As another native language, Mwotlap, gained in prominence, Volow declined. It is now believed that just one passive speaker remains in the village of Aplow.



10 ORGANS YOU CAN LIVE WITHOUT

Lung

You might be a little short of breath, but living with one lung is perfectly possible. In 1931, Rudolph Nissen, who operated on Albert Einstein, was the first surgeon to successfully remove a patient's lung.

Kidney

If illness, injury or poison prevents your kidneys from filtering your blood, they need to be removed. You can cope quite well with just one, but if you lose both, you'll need to use a dialysis machine.

Stomach

A gastrectomy – surgery to remove your stomach – can be required to treat cancer or ulcers. A total gastrectomy results in your oesophagus being connected directly to your intestine, which will have a long-term effect on diet and digestion.

Gallbladder

Sitting just below your liver, the gallbladder stores bile to break down fat in food. Gallstones caused by high cholesterol can require removal of the gallbladder.

Intestines

There are about 7.5m of small and large intestine wrapped up in your abdomen and, if necessary, all of it can come out – though absorbing nutrients afterwards may well prove to be problematic.

Eyes

Life can be harder without sight – or eyes – but clearly many people live fulfilling lives without the gift of vision.

Testicle

Reproductive organs are sometimes removed for medical reasons, typically cancer.

DID YOU KNOW?

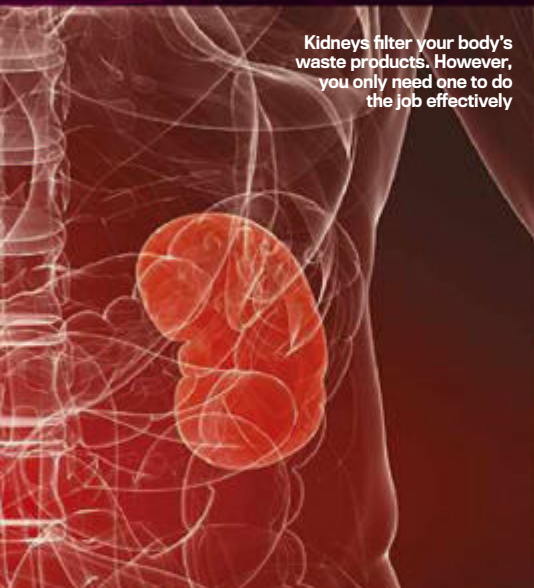
The average human body is estimated to contain more than 95,000km of blood vessels

Gallstones can be extremely painful and can result in the gallbladder being removed

Spleen

Your spleen sits just above your stomach, in the left-hand part of your body; it cleans your blood and fights infection. But if illness or injury necessitates its removal, other organs





Kidneys filter your body's waste products. However, you only need one to do the job effectively



Many people live long, healthy lives without an appendix

Appendix

Is it a vestigial organ or part of our immune system? The medical jury is still out on that question, but it's clear that its removal doesn't cause any problems.

Spleen

Your spleen sits just above your stomach, in the left-hand part of your body; it cleans your blood and fights infection. But if illness or injury necessitates its removal, other organs can compensate for its loss.

Pancreas

This small organ sits just below the stomach, and secretes hormones and digestive enzymes. In some cases of pancreatic cancer the entire organ can be removed, though the patient will require replacement hormones.

10 INVENTED LANGUAGES

Esperanto

Created by: Ludwik Lazarus Zamenhof in 1887

An international auxiliary language devised with the aim of promoting peace and understanding across the world.



Solresol

Created by: François Sudre in 1827
In the language of Solresol, words can be communicated using hand gestures, colours and musical notes as well as verbally.

Slovianski

Created by: a team of language experts in 2006
An interlanguage designed to improve communication between Slavic peoples. It's now spoken by around 2,000 people.

Sambahsa-mundialect

Created by: Olivier Simon in 2007
This new tongue has a simple grammar and incorporates vocabulary from Arabic, Chinese and Swahili among others.

Universalglot

Created by: Jean Pirro in 1868
An early - and unsuccessful - attempts at an international auxiliary language drew on vocabulary from a number of existing dialects.

Volapük

Created by: Johann Martin Schleyer in 1880
Using mostly English words as a base, it was spoken by an estimated one million people at the peak of its popularity.

Occidental

Created by: Edgar de Wahl in 1922
Drawing largely on European words, this language built a big worldwide following but fell out of favour in the years following the Second World War.

Blissymbols

Created by: Charles K Bliss in 1949
Using symbols, this written language was adopted for signs in places like airports in Canada and Sweden.

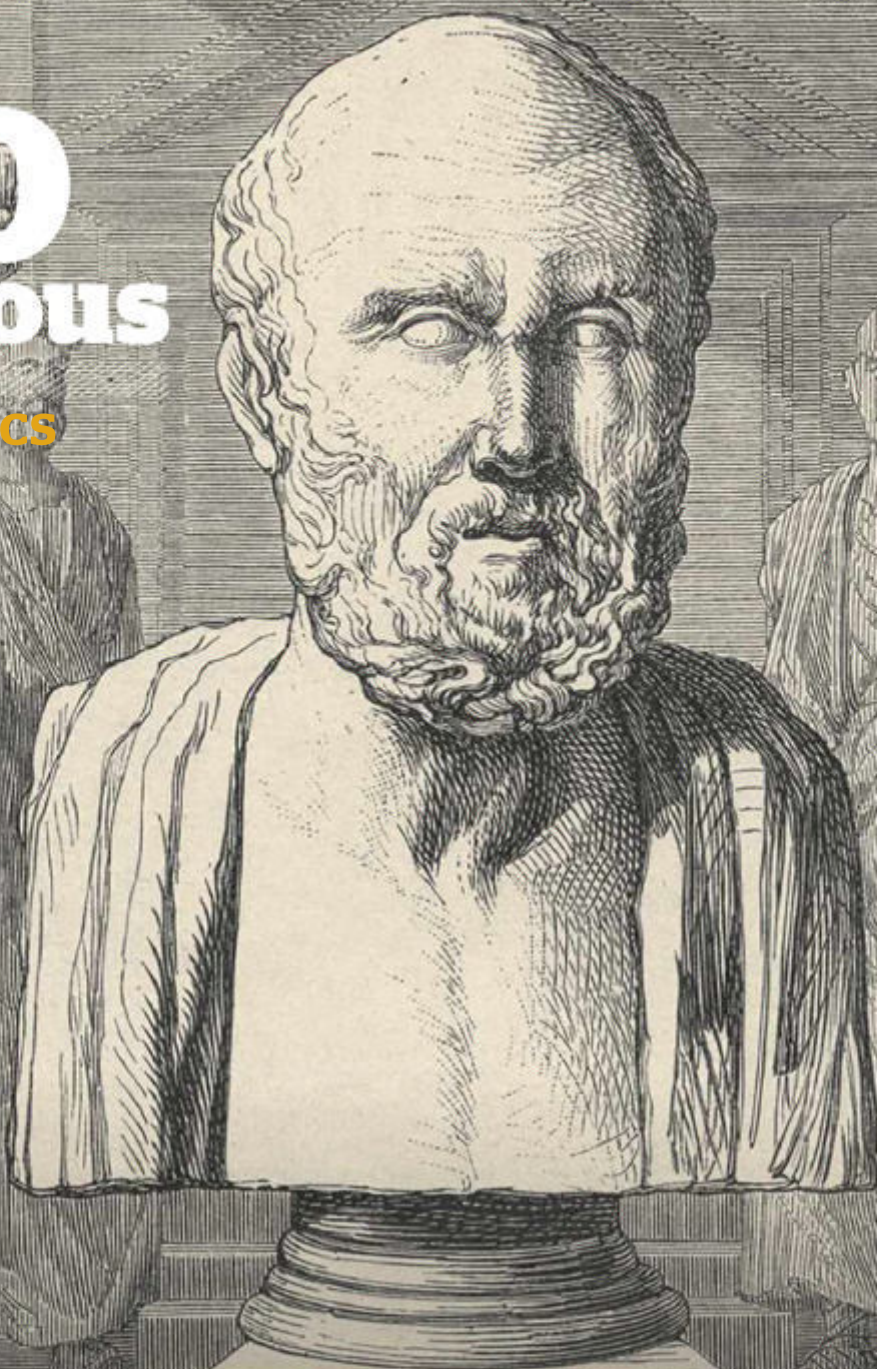
Afrihili

Created by: K A Kumi Attobrah in 1970
Afrihili took elements from English and various African languages.

Láadan

Created by: Suzette Haden Elgin in 1982
This tonal language was devised to better enable women to express their views.

10 Famous Medics



Hippocrates
460-375BC

i Attributed diseases to
natural causes

In ancient times, diseases were believed to be caused by spirits or the gods. The Greek thinker Hippocrates suggested that disease was a result of natural causes.

Joseph Lister

1827-1912

- Introduced antiseptics for sterilising wounds**

Noting that large numbers of amputee patients died of sepsis, Lister introduced the practice of sterilising wounds during surgical procedures.

James Blundell

1791-1878

- Performed first successful human blood transfusion**

In 1818, Blundell proposes the transfusion of blood from one human to another to counteract the effects of blood loss during childbirth. It's not known exactly when he performed the first transfusion, but 1829 is a commonly accepted date.



Edward Jenner

1749-1823

- Devised the first vaccine**

Jenner based his experiment on the country wisdom that victims of cowpox do not contract smallpox. He took pus from cowpox lesion and inoculated a healthy boy, who indeed proved to be immune from smallpox infection.

Ignaz Semmelweis

1818-65

- Showed hand-washing can save lives**

Known as the 'saviour of mothers', this Hungarian physician reduced mortality rates in his maternity wards by insisting that staff washed their hands in chlorinated lime solution.

René Laennec

1781-1826

- The man who invented the stethoscope**

In 1816, while examining an overweight patient, the French physician rolled some paper into a cylinder to allow him to hear her heartbeat. He later refined this concept, using a hollow wooden tube.

Galen

129-c200

- Responsible for introducing experimental medicine**

The theories of this Greek-speaking Roman physician hugely influenced medicine for more than a millennium. He was also the personal physician to several emperors.

Charles Drew

1904-50

- Developed large-scale blood banks**

Drew undertook extensive research into techniques for storing blood. He developed large-scale blood banks during the Second World War that saved thousands of soldiers' lives.

Henry Gray

1827-61

- Published the most influential medical textbook**

In 1858, the English anatomist published his textbook *Anatomy: Descriptive and Surgical* - which became known in later editions as *Gray's Anatomy*. It was an instant success and is still the most widely used anatomy textbook.

Christiaan Barnard

1922-2001

- Performed first successful human heart transplant**

This South African surgeon worked with transplant pioneer Norman Shumway in the USA before returning home to conduct the first human heart transplant in 1967. The patient, Louis Washkansky, lived for a further 18 days.





Trans-Siberian railroad

Russia
Length: 9,289km

Construction on the world's longest railway line began in 1891 and, by 1916, had successfully connected Moscow in the west with Vladivostok on Russia's east coast, 9,289km away.

Burj Khalifa

United Arab Emirates
Height: 828m

The current tallest building in the world (boasting a full 163 storeys), this iconic skyscraper took 330,000 cubic metres of concrete and 39,000 tonnes of steel to build. The tower also boasts more than 24,000 windows.

Akashi Kaikyo bridge

Japan
Length: 3,911m

Almost half of the entire length of this incredible structure, which boasts the longest central span of any suspension bridge in the world, is suspended over the waters of the Akashi Strait and carries a six-lane highway.

TECHNOLOGY



Inventions, gadgets, gizmos, materials - the world of technology is fast-moving and constantly surprising. The top tens on the next few pages demonstrate the range of applications for scientific developments

10 ENGINEERING WONDERS OF THE MODERN WORLD

Jiaozhou Bay Bridge Qingdao, China

Length: 26,707m



The bridge across China's Jiaozhou Bay is the main section of a complex comprising a 41.58km roadway connecting the districts of Qingdao and Huangdao. Opened in 2011, the world's longest bridge over water cost £5.5billion to build; its construction required 10,000 workers, 450,000 tonnes of steel and 2.3 million m³ of concrete.

Panama Canal Panama

Length: 77.1km
This man-made channel connecting the Atlantic and Pacific Oceans opened in 1914. Some 42,000 workers excavated the canal, digging enough earth to bury Manhattan Island. Today, more than 14,500 vessels use the waterway every year.

Millau Viaduct France

Length: 2,460m
Height: 343m
The world's tallest bridge spans the valley of the River Tarn, carrying a four-lane highway 270m above the valley floor. Higher than the Eiffel Tower, the bridge was completed in 2004 after three years of construction at a cost of €400 million.

Bailong Elevator China

Height: 330m
Built into a cliff face in Zhangjiajie National Forest Park, the Bailong Elevator (aka the 'Hundred Dragons Elevator') is the world's highest outdoor lift. The 330m ascent takes around a minute in one of three glass cabins.

Three Gorges Dam China

Height: 180m
The barrier on China's Yangtze River is far from the biggest dam in the world, but is a crucial part of the world's largest hydroelectric power station with a generating capacity of 22,500mW. To make way for the reservoir, three cities had to be flooded.

Large Hadron Collider France/Switzerland

Length/circumference: 27km
Buried 100m below France and Switzerland is the world's most powerful particle accelerator, designed to recreate the conditions that existed shortly after the Big Bang. It weighs more than 38,000 tonnes.

Gotthard Base Tunnel Switzerland

Length: 57km
Running underneath the Swiss Alps, when completed this will be the world's longest rail tunnel. Due to open in 2016, this will eclipse both the 53.85km-long Seikan Tunnel in Japan and the 50km-long Channel Tunnel.

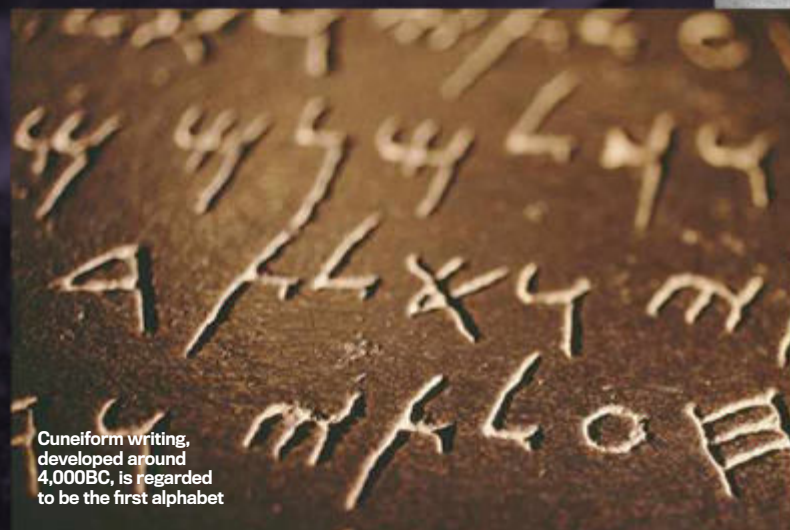
10 CRUCIAL COMMUNICATION BREAKTHROUGHS

The Alphabet

When: 4,000-1,200BC

The ability to record information was arguably most significant breakthrough in human communication after speech. Sumerian cuneiform, a pictographic writing system denoting concepts and syllables, evolved around 4,000BC. It was replaced by the Phoenician alphabet comprising characters that represent single sounds.

Guglielmo Marconi (standing), the godfather of telecommunication



Cuneiform writing, developed around 4,000BC, is regarded to be the first alphabet



Postal Service

27BC-AD 14

It's thought that the Persians were the first to introduce a kind of postal service around 550BC. But the earliest and best-documented evidence of such a system, enabling the public to send written messages, dates from the reign of the Roman emperor Augustus.

Paper

AD 105

Official records credit Chinese inventor Cai Lun with the first production of paper, although archaeological research suggests that paper was being used in the country much earlier than that.

Gutenberg Press

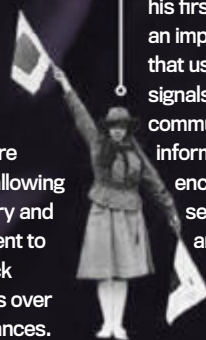
1450

For centuries, literacy and literature were restricted to religious scholars and wealthy intellectuals. Then German Johannes Gutenberg invented the metal printing press with movable type, enabling multiple copies of publications to be made quickly and cheaply.

Semaphore

1792

By peppering 566 towers topped with mechanical arms throughout his native France, Claude Chappe invented the first optical semaphore system, allowing the military and government to send quick messages over vast distances.



Morse Code

1840

The telegraph had already been invented, but in 1840 American painter Samuel Morse filed his first patent for an improved device that used electric signals to communicate information encoded as a series of dots and dashes.

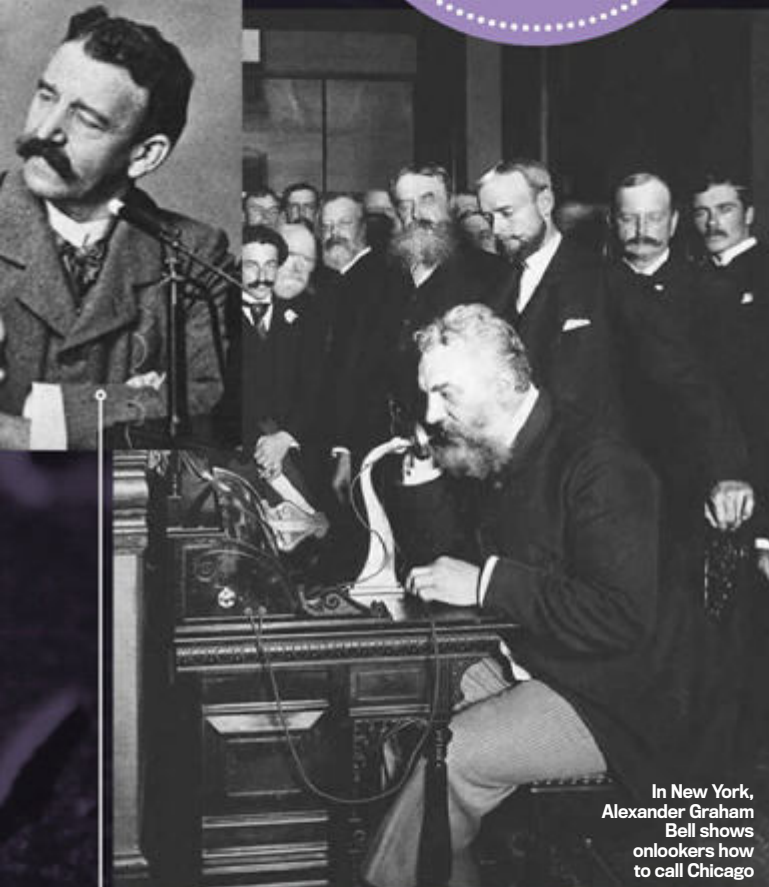
Telephone

1876

Many people lay claim to the invention of the telephone, but Alexander Graham Bell filed the first patent for a device that enabled people in different places to talk to each other.

DID YOU KNOW?

The first computer mouse, invented by Doug Engelbart in California in 1964, was carved from wood



In New York, Alexander Graham Bell shows onlookers how to call Chicago

Wireless transmissions 1895

Guglielmo Marconi built on the work of others to develop and improve a system using electromagnetic radiation to transmit messages wirelessly. In 1895, he sent and received signals over a distance of almost 2.5km. By 1901, he was able to communicate across the Atlantic.

Television 1925

The first equipment allowing the viewing of live pictures, rather than pre-recorded footage, appeared in 1925. Similar technology had been developed over the previous 50 years, but Scotsman John Logie Baird made the first public demonstration of television in 1925.

Arpanet 1969

Modern networks were born when technology allowed computers to connect and communicate with each other. That technology led to the creation of Arpanet (Advanced Research Projects Agency Network), a system to help US research labs exchange information, laying the foundations for the internet.



TOP 10 COUNTRIES WITH HIGHEST SMARTPHONE PENETRATION

01

United Arab Emirates
73.8% of population owns a smartphone

02

South Korea
73% of population owns a smartphone

03

Saudi Arabia
72.8% of population owns a smartphone

04

Singapore
71.7% of population owns a smartphone

05

Norway
67.5% of population owns a smartphone

06

Australia
64.6% of population owns a smartphone

07

Sweden
63% of population owns a smartphone

08

Hong Kong
62.8% of population owns a smartphone

09

UK
62.2% of population owns a smartphone

10

Denmark
59% of population owns a smartphone

*Source: Our Mobile Planet by Google. Survey conducted Q1 2013.

10 INVENTORS KILLED BY THEIR OWN INVENTIONS



Submarine setback **Horace Lawson Hunley** (died 1863, aged 40)

The American marine engineer's career was brought to an end when the hand-powered submarine he was developing sank. He and the seven other crew members drowned.



Parachute pratfall **Franz Reichelt** (died 1912, aged 32)

An Austrian-French tailor and inventor, Reichelt was determined to test his own design for a wearable parachute by jumping from the Eiffel Tower. The parachute failed to deploy and he was killed on impact.



Pulley problem **Thomas Midgley Jr** (died 1944, aged 55)

The polio-suffering chemist/engineer developed a pulley system to help assistants lift him from his bed, but died of strangulation when he became entangled in its ropes.



Glider gaffe **Otto Lilienthal** (died 1896, aged 48)

The German was a pioneer of unpowered aviation, conducting numerous test flights. He died when a hang glider that he'd previously flown successfully stalled, crashing from a height of 15m and breaking his neck.



Rocket reversal **Max Valier** (died 1930, aged 35)

This Austrian rocket technology pioneer worked with Fritz von Opel on rocket-powered aircraft and cars, but Valier was killed when an alcohol-fuelled rocket he was working on exploded during testing.



Balloon blunder **Jean-François Pilâtre de Rozier** (died 1785, aged 31)

In 1783, this French aviation pioneer suffered the first known air-crash fatality when the balloon flown by him and Pierre Romain suddenly deflated and plunged to the ground.



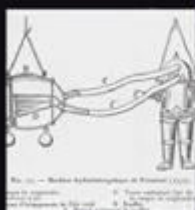
Printing pain **William Bullock** (died 1867, aged 54)

In 1865, the US inventor unveiled the first web rotary press, fed by a continuous roll of paper. Two years later, his leg became caught in it. He died during an attempted amputation.



Maiden misadventure **James Douglas** (died 1581, aged 65)

The 4th Earl of Morton is believed to have introduced the 'Maiden', a primitive guillotine, to Scotland. He himself was later executed by the Maiden for his role in the murder of Lord Darnley.



Diving disaster **Sieur Fréminet** (died 1772, age unknown)

Testing his own diving suit that recycled exhaled air, Frenchman Fréminet suffocated a mere 20 minutes into his dive when the oxygen in the suit was depleted.



Train trouble **Valerian Abakovsky** (died 1921, aged 25)

The Aerowagon was a railcar powered by an aircraft engine. On the return leg of its first journey, the Aerowagon derailed, killing all on board - including its Latvian inventor.

10 RARE ELEMENTS FOUND IN YOUR HOME



Europium
Symbol: Eu
Atomic number: 63
Used in nuclear reactors as well as low-energy light bulbs and TV sets. Discovered by France's Eugène-Anatole Demarçay in 1896.



Terbium
Symbol: Tb
Atomic number: 65
Found in LCD screens and solid-state memory devices (including USB drives). Swedish chemist Carl Mosander discovered the soft, malleable and ductile metal in 1843.



Lanthanum
Symbol: La
Atomic number: 57
Another of Carl Mosander's discoveries, this is one of the metals used in the nickel-metal hydride (NiMH) batteries found in some smartphones, laptops and electric cars.



Neodymium
Symbol: Nd
Atomic number: 60
Neodymium makes excellent magnets and has been put to use in computer hard drives, stereo speakers and electric motors. It's also used to colour glass.



Yttrium
Symbol: Y
Atomic number: 39
Yttrium is a metal that can be added to glass to make it heat- and shock-resistant; it is found in many camera lenses.



Samarium
Symbol: Sm
Atomic number: 62
Discovered by Frenchman Paul-Émile Lecoq de Boisbaudran in 1879, this metal makes great magnets, used in headphones and electric guitars.



Cerium
Symbol: Ce
Atomic number: 58
Replacing cadmium in pigments used in domestic products, red plastic toys or homewares are likely to contain cerium, which is also found in compact discs, flat-screen TVs and low-energy light bulbs.



Erbium
Symbol: Er
Atomic number: 68
Another Carl Mosander discovery, this silver metal has a pink tinge. It's useful for colouring photographic filters but also improves the function of optical fibres for broadband internet connections.



Dysprosium
Symbol: Dy
Atomic number: 66
Paul-Émile Lecoq de Boisbaudran also discovered dysprosium. Besides nuclear reactor control rods, dysprosium is used in car headlights and the electric motors found in hybrid vehicles such as the Toyota Prius.



Selenium
Symbol: Se
Atomic number: 34
Many devices powered by solar cells contain selenium. You might also find it in your bathroom - it's used in some anti-dandruff shampoos.

10 NASA TECHNOLOGIES WITH EARTHLY APPLICATIONS

Artificial heart pumps Introduced to commercial market: 1998

Patients awaiting heart transplants can be kept alive with a left ventricular assist device (LVAD). Smaller than other heart pumps and battery operated, this instrument is based on the fuel pumps used in NASA's rocket engines.

Scratch-resistant lenses Introduced to commercial market: 1983

These evolved from an experiment to improve water purification on spacecraft. The result was a coating that rendered spectacle lenses almost impervious to abrasion.

Fire-retardant paint Introduced to commercial market: 1974

The coating on the Apollo spacecrafts' heat shields was used for fire-retardant paints for aircraft. The paint has also been employed to reinforce steel structures in buildings.

Memory foam Introduced to commercial market: 1969

In 1966, NASA contracted aeronautical engineer Charles Yost to improve aeroplane seating in the hope of providing better crash protection. He came up with memory foam, a material that could absorb high-energy impacts but also provide greater comfort by moulding itself to any object placed upon it.



The foam that never forgets - another NASA creation

Cardio-muscular conditioning machines Introduced to commercial market: 1991

The machine dubbed the 'Shuttle 2000-1' was developed to give astronauts an effective workout, helping to combat muscle wasting that can result from life in zero gravity. The same machine is used for physiotherapy and to help elderly people exercise.



THE 10 MOST POWERFUL SUPER-COMPUTERS

01

Tianhe-2
(MilkyWay-2)
Where: National Super Computer Center, Guangzhou, China
Rmax: 33.86 petaflops

02

Titan
Where: DOE/SC/Oak Ridge National Laboratory, USA
Rmax: 17.59 petaflops

03

Sequoia
Where: DOE/NNSA/Lawrence Livermore National Laboratory, USA
Rmax: 17.17 petaflops

04

K Computer
Where: RIKEN Advanced Institute for Computational Science (AICS), Japan
Rmax: 10.51 petaflops

Space blanket Introduced to commercial market: 1980

The same material that protects astronomical objects ranging from the Hubble telescope to the Mars Rovers against the extreme temperatures of space also keeps marathon finishers warm. By coating a thin plastic sheet with aluminium, a lightweight material was created that insulates by reflecting heat.

Smart clothing Introduced to commercial market: 1997

Smart clothing is made from phase-change fabric, material that incorporates microscopic capsules filled with a chemical that switches between a liquid and a gas depending on the temperature. NASA uses it as a liner in astronaut gloves and it's now found in bedding, clothing and footwear.

Infrared thermometers Introduced to commercial market: 1991

Astronomers gauge the temperature of planets millions of light-years away by measuring the thermal radiation emitted. The technology developed to monitor that radiation powers infrared thermometers that measure your body temperature by checking the heat emitted from your eardrum.

Anti-fog coating Introduced to commercial market: 1967

Skiers wearing goggles on snowy slopes bless this technology that helps prevent eyewear from misting up. This technology is based on the coating developed to stop condensation building up on plastic or glass surfaces in NASA's Gemini spacecraft.

Maximum absorbency garment Introduced to commercial market: 2009

Otherwise known as the 'space nappy', the maximum absorbency garment was designed to enable astronauts to relieve themselves comfortably during prolonged spacewalks. Capable of soaking up approximately two litres of liquid, the 'space nappy' also offers a solution for people suffering from incontinence.



DID YOU KNOW?

Prolific inventor
Thomas Edison filed 2,332
worldwide patents during
his lifetime

05

Mira

Where: DOE/SC/Argonne National Laboratory, USA

Rmax: 8.59 petaflops

06

Piz Daint

Where: Swiss National Supercomputing Centre (CSCS), Switzerland

Rmax: 6.27 petaflops

07

Stampede

Where: Texas Advanced Computing Center/University of Texas, USA

Rmax: 5.17 petaflops

08

JUQUEEN

Where: Forschungszentrum Juelich (FZJ), Germany

Rmax: 5.01 petaflops

09

Vulcan

Where: DOE/NNSA/Lawrence Livermore National Laboratory, USA

Rmax: 4.29 petaflops

10

SuperMUC

Where: Leibniz Rechenzentrum, Germany

Rmax: 2.90 petaflops

* Assessed using Linpack benchmark by Top 100 Supercomputer Sites (www.top500.org) November 2013. Processing power measured as Rmax petaflops (one petaflop = one quadrillion calculations per second).

10 SCI-FI PREDICTIONS THAT CAME TRUE



Television

Predicted by: Mark Twain, *From the London Times of 1904*, published 1898

The first television was produced in the 1920s, but Mark Twain had already described the telectroscope that would "make the daily doings of the globe visible to everybody".



Electronic book

Predicted by: Stanislaw Lem, *Return From the Stars*, published 1961

Instead of hardcovers and paperbacks, Polish author Lem foresaw books in crystal form, read on devices called 'optons' that display one page of text at a time.



Tablet device

Predicted by: Arthur C Clarke, *2001: A Space Odyssey*, published 1968

Surfing the internet on a portable device was dreamed up long before the turn of the millennium. In the late 1960s, Clarke gave his fictional astronauts 'newspads' so they could keep up to date with the goings-on back home.



Tank

Predicted by: HG Wells, *The Land Ironclads*, published 1903

The tank made its battlefield debut in 1916, but was envisaged by Wells as an all-terrain, armoured vehicle carrying powerful guns. Winston Churchill later credited Wells for the idea, but the author's vehicle was inspired by Brahmah Joseph Diplock's pedrail locomotive.



Earphones

Predicted by: Ray Bradbury, *Fahrenheit 451*, published 1953

Though the personal stereo didn't appear until 1977, in the early '50s Bradbury described earphones piping in constant music and talk.



Atomic bomb

Predicted by: HG Wells, *The World Set Free*, published 1914

Wells envisioned a nuclear bomb that would explode continuously for 17 days and have longer-term effects through nuclear fallout.



THE 10 BIGGEST OPTICAL REFLECTOR TELESCOPES

01

Gran Telescopio Canarias (GTC)

Aperture: 10.4m
Location: La Palma, Canary Islands, Spain
Built: 2008

02

Keck I & II
Aperture: 10m (each)

Location: Mauna Kea, Hawaii, USA
Built: 1993 (I), 1996 (II)

03

South African Large Telescope (SALT)

Aperture: 9.8m
Location: Sutherland, South Africa
Built: 2005

04

Hobby-Eberly Telescope
Aperture: 9.2m

Location: Davis Mountains, Texas, USA
Built: 1997



Scuba-diving equipment

Predicted by: Jules Verne, *Twenty Thousand Leagues Under the Sea*, published 1870

Verne described a means of breathing underwater using apparatus that, unlike all existing equipment, didn't take its air supply from the surface. His idea came from the system developed in the 1860s by French duo Benoit Rouquayrol and Auguste Denayrouze to save miners trapped underground.



MOON LANDING

Predicted by: Jules Verne, *From The Earth To The Moon*, published 1865

More than 100 years before Armstrong's lunar stroll, Verne had envisioned a trip to the Moon – though his protagonists were fired from an enormous cannon at a launch site in Florida.



Video calls

Predicted by: Albert Robida, *Le Vingtième Siècle. La Vie Électrique*, published 1890

The first public videophone service launched in Germany in 1936, and EM Forster described a communication system that transmitted both audio and visual signals in his short story *The Machine Stops*, published in 1909. Yet this French author's 1890 book mentions a similar device called 'le téléphonescope'.



Surveillance

Predicted by: George Orwell, *Nineteen Eighty-Four*, published 1949

CCTV cameras, internet cookies, loyalty cards, NSA data monitoring, social media... The Big Brother dreamed up by Orwell in his dystopian novel comes in many guises today.

DID YOU KNOW?

Google's original name was BackRub, "a 'web crawler' designed to traverse the web"



04

Large Binocular Telescope (LBT)
Aperture: 8.4m (x2)
Location: Mt Graham, Arizona, USA
Built: 2004

06=

Subaru (JNLT)
Aperture: 8.2m
Location: Mauna Kea, Hawaii, USA
Built: 1999

06=

VLT UT1, 2, 3 & 4
Aperture: 8.2m (x4)
Location: Cerro Paranal, Atacama Desert, Chile
Built: 1998 (UT10)

08=

Gemini North
Aperture: 8.1m
Location: Mauna Kea, Hawaii, USA
Built: 1999

08=

Gemini South
Aperture: 8.1m
Location: Cerro Pachón, Chile
Built: 2000

10

MMT
Aperture: 6.5m
Location: Mt Hopkins, Arizona, USA
Built: 2000

10 NEW MIRACLE MATERIALS

Ferrofluids

Applications: spacecraft, telescopes, cancer treatments

By suspending microscopic particles of iron compounds in a fluid, scientists have created a shape-shifting liquid metal controlled by magnetic fields. Ferrofluids are already being used in stereo speakers and computer hard disks, but may soon find their way into spacecraft controls, telescopes and cancer treatments.

The shape-shifting liquid metals called ferrofluids form extraordinary structures



Silicene

Applications: microchips, digital storage, catalysts for cleaning up pollution

Created in 2012, silicene is the silicon equivalent to graphene – a single layer of silicon atoms. It allows electrons to pass through it almost entirely unhindered, and is compatible with the silicon circuitry used in microelectronics.

Programmable matter

Applications: self-assembling robots, universal toolkits

In a lab at the Massachusetts Institute of Technology are sheets of a special metal, called shape-memory alloy, with thin electronic circuit boards printed on them. When electricity passes through the circuit, the metal folds itself into predetermined shapes. Change the current's direction and, for instance, a screwdriver turns into a robot.

DNA hydrogels

Applications: wound dressing, scaffolds for engineering tissue, water-activated switches

A team at Cornell University has designed synthetic strands of DNA that link in specific ways, creating a gel that forms predetermined shapes on the addition of water. As the gel absorbs water, strands with complementary coding lock onto each other, moulding the shape of the gel.

Polyurethane block copolymer

Applications: bulletproof windscreens and armour, satellite protection

A 3cm-thick piece of this substance will stop a bullet without the slightest crack or scratch, absorbing the projectile's energy by melting at the point of impact then instantly sealing over the embedded round as it cools.

Ionic liquids

Applications: green cleaning solvent, fuel cells, solar cells

Also known as fluid salts, these substances melt at temperatures below 100°C without any chemical decomposition. As such, they're useful as charge-carrying liquids for batteries or solar cells and, perhaps more importantly, as solvents – they don't emit any harmful vapours.

Graphene

Applications: stronger, lighter composites, flexible computer screens and batteries, sensors, medical imaging

Despite being only a single atom thick, graphene – densely packed, flat carbon – is the strongest material discovered so far. It also happens to be one of the best conductors of electricity.

Gold nanoparticles

Application: disease detection

Large quantities of minuscule gold particles change colour when brought into contact with even the tiniest amounts of certain chemicals, assisting with the detection of diseases – such as cancer, AIDS and malaria – more simply, more cheaply and earlier than current methods.

Metamaterials

Applications: cloaking devices, optical computing, spacecraft shielding, medical imaging

By carefully manipulating the nanostructures within certain substances scientists can engineer specific properties into them. The resulting 'metamaterials' can do remarkable things, such as bend light around them rather than absorb or reflect it. Such metamaterials are involved with designs for invisibility cloaks.

Self-healing concrete

Applications: tunnels, viaducts, roads, marine structures

Concrete laced with bacteria and nutrients could increase the lifespan of buildings. Water seeping into cracks activates the bacteria, which feed on the nutrients and secrete tough calcium carbonate (limestone) that fills the cavity.

10 Famous Visionary science-fiction writers

Sir Arthur C Clarke

1917-2008

i Co-writer of the film
2001: A Space Odyssey

As well as earning a number of awards for his writing, the British author - who spent most of his later years in Sri Lanka - was something of a prophet, predicting that computers would be used for online shopping and banking.



Isaac Asimov

1920-92

i Wrote or edited more than
500 influential books

Most famous for writing the *Foundation* series, the Russian author is often considered one of the 'Big Three' sci-fi writers, along with Heinlein and Clarke. His science-fiction short story *Nightfall* was voted the best of all time. A crater on Mars is named after Asimov - the highest accolade for a sci-fi writer?

Robert A Heinlein

1907-88

i First Science Fiction Writers
Grand Master

Beginning his career as a magazine writer, this American author went on to pen four overlapping series, including the *Future History* books. His novels explore a range of themes including sex, race, politics and the military - often sparking important debates on these topics.

Ray Bradbury

1920-2012

i Created visions of
a dystopian future

One of the most celebrated American writers, many of Bradbury's stories were adapted for other media - most famously, *Fahrenheit 451*, envisaging a future state that burns books. Between 1985 and 1992, he also presented *The Ray Bradbury Theatre* television show, for which he adapted 65 of his own stories.

Phillip K Dick

1928-82

i Wrote novels inspiring *Blade Runner* and *Total Recall*

As well as publishing 44 novels, Dick also wrote around 120 short stories. The American author's works have inspired a string of hit films including *Blade Runner*, *Total Recall* and *Minority Report*.

EE 'Doc' Smith

1890-1965

i Best known for the *Lensman*
and *Skylark* series

This American author is sometimes known as the 'first nova' of 20th-century science fiction. He was particularly popular with scientists, engineers and military men - possibly because a common theme in his novels was the difficulty of maintaining military secrecy.

Jack Williamson

1908-2006

i Wrote the *Legion of Space* series

Williamson was only the second named Grand Master of Science Fiction, from the Science Fiction Writers of America. The Eastern New Mexico University library is home to the Jack Williamson Science Fiction Library.

Harlan Ellison

1934-present

i Multi award-winning author
and editor

This American writer has published more than 1,700 short stories, novellas and essays, as well as many film and TV scripts including much-lauded *Star Trek* episodes. He's the only three-time winner of the Nebula Award for Best Short Story.

Frank Herbert

1920-86

i Writer of the *Dune* saga

Herbert used many of his novels to explore and combat complex ideas based around philosophy, leadership and religion, and his work attracted a fanatical fan base. *Dune* became a major film directed by David Lynch.

Frederik Pohl

1919-2013

i Author with a career
spanning 75 years

This American writer's first published work was a short story produced in 1937; his last novel was printed in 2011. Pohl was awarded the Damon Knight Memorial Grand Master Award by the Science Fiction Writers of America in 1993.

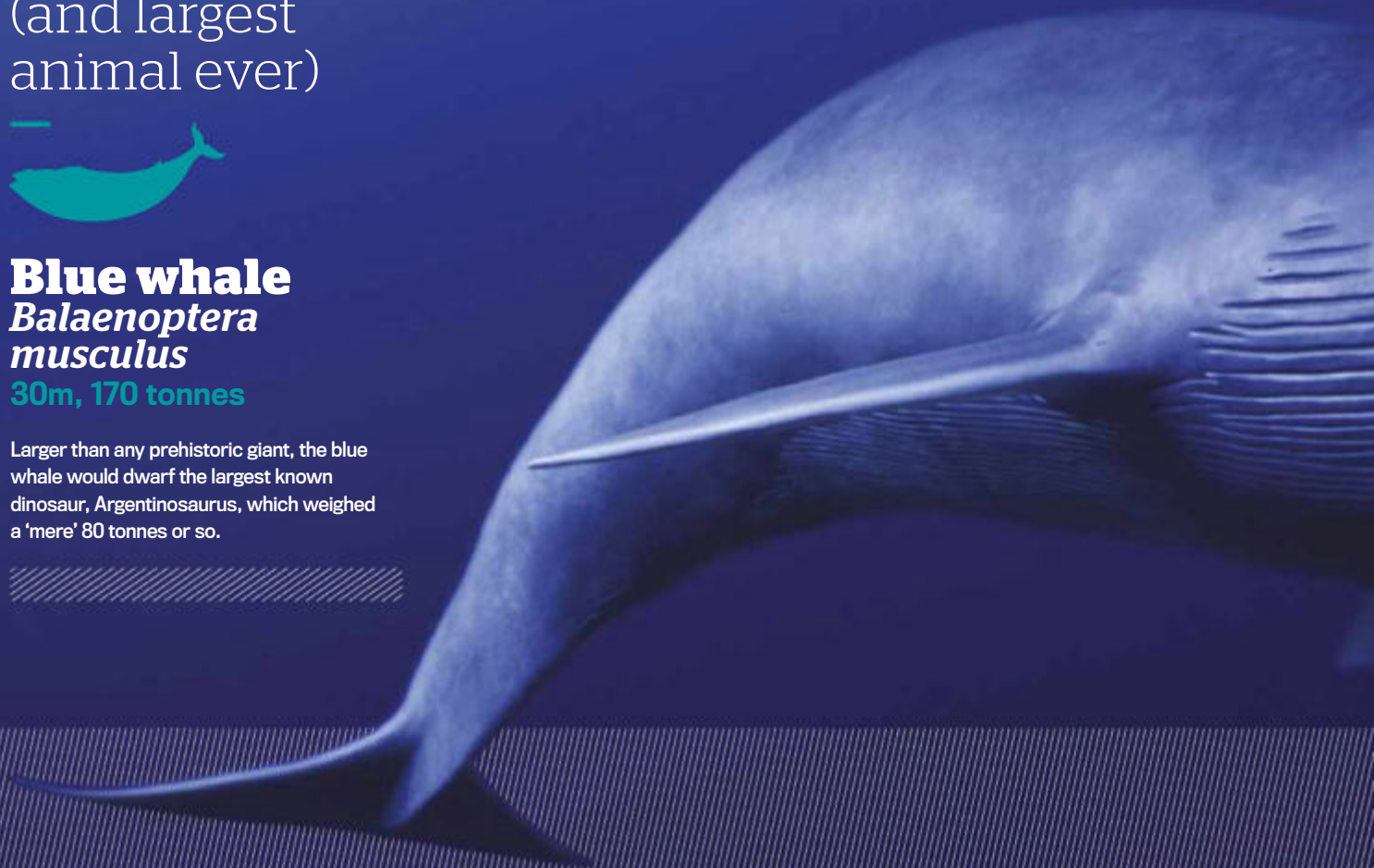
10 OUTSIZED ANIMALS

Largest mammal (and largest animal ever)



Blue whale *Balaenoptera musculus* 30m, 170 tonnes

Larger than any prehistoric giant, the blue whale would dwarf the largest known dinosaur, Argentinosaurus, which weighed a 'mere' 80 tonnes or so.



Largest land mammal

African elephant
Loxodonta africana
7.5m, 6 tonnes



Largest reptile

Saltwater crocodile
Crocodylus porosus
6.7m, 2 tonnes



Largest snake

Green anaconda
Eunectes murinus
6.6m, 70kg



Largest dinosaur

Argentinosaurus
Estimated to be 30-35m long, 80-100 tonnes



Largest bird

Ostrich
Struthio camelus
2.1-2.8m, 145kg



Largest insect

Goliath beetle
Goliathus spp.
60-110mm, 100g

ANIMAL KINGDOM



From monstrous mammals to minute microbes, ancient reptiles and super-strong insects, the diverse and dazzling world of wildlife is full of surprises



Largest fish

Whale shark
Rhincodon typus
12.65m, 21.5 tonnes



Largest amphibian

Chinese giant salamander
Andrias davidianus
2m, 30kg



Largest carnivore

Southern elephant seal
Mirounga leonina
3m, 4 tonnes

DID YOU KNOW?

Giant isopods - 14-legged deep-sea critters a little like giant woodlice - can grow to 76cm long and 1.7kg

10 SUPER-FAST ANIMALS

Overall speed

Peregrine falcon

Falco peregrinus

389km/h (fastest recorded)

The peregrine regular exceeds 322km/h during stoops (hunting dives) - though doesn't come close to that speed in level flight.



Bird (flapping flight)

White-throated
needle tail
*Hirundapus
caudacutus*
169km/h

Marine reptile

Leatherback
sea turtle
*Dermochelys
coriacea*
35km/h
A teardrop-shaped body gives this reptile a hydrodynamic advantage.

Flying mammal

Mexican free-tailed bat
*Tadarida
brasiliensis*
96.5km/h

Land mammal

Cheetah
*Acinonyx
jubatus*
120km/h
The fastest land animal on Earth can maintain this speed for bursts of no longer than 60 seconds.

Land herbivore

Pronghorn
*Antilocapra
americana*
88.5km/h
This antelope-like creature can maintain speeds of 56km/h for several kilometres.

Fish

Indo-Pacific sailfish
*Istiophorus
albicans*
111km/h
The title of fastest fish is hotly disputed; the highest estimates for this species date from the 1920s.

Insect

Horsefly
*Chrysops
relictus*
145km/h

Marine mammal

Common
dolphin
Delphinus spp.
64km/h

Land reptile

Black
iguana
*Ctenosaura
similis*
34.9km/h

The black iguana is the fastest land-based reptile



300kg

The weight that an African elephant can carry with its trunk. The trunk contains around 4,000 muscles

10 SUPER-STRONG ANIMALS



- 01 Dung beetle**
Onthophagus taurus
Hauls 1,141 times own weight
In 2010, researchers Rob Knell and Leigh Simmons demonstrated that the strongest males can pull a load 1,141 times its own weight.



- 02 Hercules beetle**
Dynastes hercules
Lifts 850 times own weight
The hefty insects known as rhinoceros beetles carry huge loads - anecdotal evidence suggests this species can lug 850 times its own weight.



- 03 Leaf-cutter ants**
Atta cephalotes
Lifts 50 times its own weight
The various species of leafcutter ant carry relatively enormous chunks of leaves back to their nest to fertilise the fungi on which they feed.



- 04 Eastern gorilla**
Gorilla beringei
Lifts 10 times own weight
Big male gorillas - silverbacks - are immensely strong. By comparison, the strongest human weightlifters can lift two or three times their own weight.



- 05 Crowned hawk-eagle**
Stephanoaetus coronatus
Lifts four times own weight
One of Africa's most powerful raptors, the crowned hawk-eagle preys on mammals such as monkeys and bushbucks that weigh up to 30kg.



- 06 Tiger**
Panthera tigris
Lifts double own weight
Prey varies across the ranges of the subspecies, but the largest tigers have been known to hunt and carry water buffalo and even young elephants.



- 07 Asian elephant**
Elephas maximus
Pulls 170% of own weight
But Asian elephants used in the timber industry have hauled logs weighing up to 9 tonnes - nearly twice as heavy as a large male tusker.



- 08 Ox**
Bos primigenius
Pulls 150% of own weight
The phrase 'strong as an ox' is well coined: for millennia oxen have been used for hauling heavy loads and ploughing heavy soil.



- 09 Green anaconda**
Eunectes murinus
Constricts at 90psi
Though figures are debated, the green anaconda is believed to be the world's largest snake, and has the most powerful squeeze at a reported 90psi.



- 10 Brown bear**
Ursus arctos
Five times as strong as a human
Grizzly bears grow to 500kg and over, and prey on large mammals such as moose, elk and even black bears.

10 EXTREME MATING PRACTICES

Greater flamingo *Phoenicopterus roseus* Applies pink make-up

It's long been known that the characteristic pink hue of flamingos' feathers is derived from carotenoid pigments in the shrimps and other plankton they eat. But in 2010 scientists discovered that greater flamingos actively apply pigment, secreted from a gland at their rear, to their feathers during preening - and reapply regularly to prevent it from fading in the sun.

Anglerfish

Ceratioidei

Males are parasites, latching onto females and releasing sperm during spawning.

Bedbug

Cimex lectularius

A male pierces a female's abdomen for traumatic insemination.

Common garter snake

Thamnophis sirtalis

Thousands of snakes writhe in a mass mating ritual.

Snails & slugs

Pulmonata

Many land-dwelling hermaphrodite slugs and snails fire 'love darts' into prospective mates during courtship.

Praying mantis

Mantodea

Perhaps 30% of courting male mantids are eaten by females during or after mating.

Wasp spider

Argiope bruennichi

The male breaks off his own pedipalp (penis equivalent), blocking the female's reproductive tract.

Porcupine

Erethizon dorsatum

A courting male will urinate over his prospective partner before mating.

Squid

Teuthida

The males of some squid species 'stab' females to inject them with sperm.

Green spoonworm

Bonellia viridis

Each male lives in a female's genital sac.



10 MOST PAINFUL INSECT STINGS



4+

Bullet ant
Paraponera clavata
"Pure, intense, brilliant pain. Like fire-walking over flaming charcoal with a 3-inch rusty nail grinding into your heel."

4.0

Tarantula hawk
Pepsis formosa
"Blinding, fierce, shockingly electric. A hair drier has been dropped into your bubble bath."

3.0

Paper wasp
Polistes spp.
"Caustic and burning. Distinctly bitter aftertaste. Like spilling a beaker of hydrochloric acid on a paper cut."

3.0

Red harvester ant
Pogonomyrmex barbatus
"Bold and unrelenting. Somebody is using a drill to excavate your ingrown toenail."

2.0

European honey bee
Apis mellifera
"The sensation is like a matchhead that flips off and burns on your skin."

2.0

Yellow jacket
Vespula spp.
"Hot and smoky, almost irreverent. Imagine WC Fields extinguishing a cigar on your tongue."

2.0

Bald-faced hornet
Dolichovespula maculata
"Rich, hearty, slightly crunchy. Similar to getting your hand mashed in a revolving door."

1.8

Scacia ant
Pseudomyrmex ferruginea
"A rare, piercing, elevated sort of pain. Someone has fired a staple into your cheek."

1.2

Fire ant
Solenopsis spp.
"Sharp, mildly alarming. Like walking across a shag carpet and reaching for the light switch."

1.0

Sweat bee
Halictidae
"Light, ephemeral, almost fruity. A tiny spark has singed a single hair on your arm."

In 1990, American entomologist Dr. Justin O Schmidt compiled the Schmidt Sting Pain Index in an attempt to quantify the most agonising insect stings and bites, based on years of research. Though subjective, this is the most comprehensive ranking, rated using a scale of 1 to 4.

10 LONGEST ANIMAL MIGRATIONS

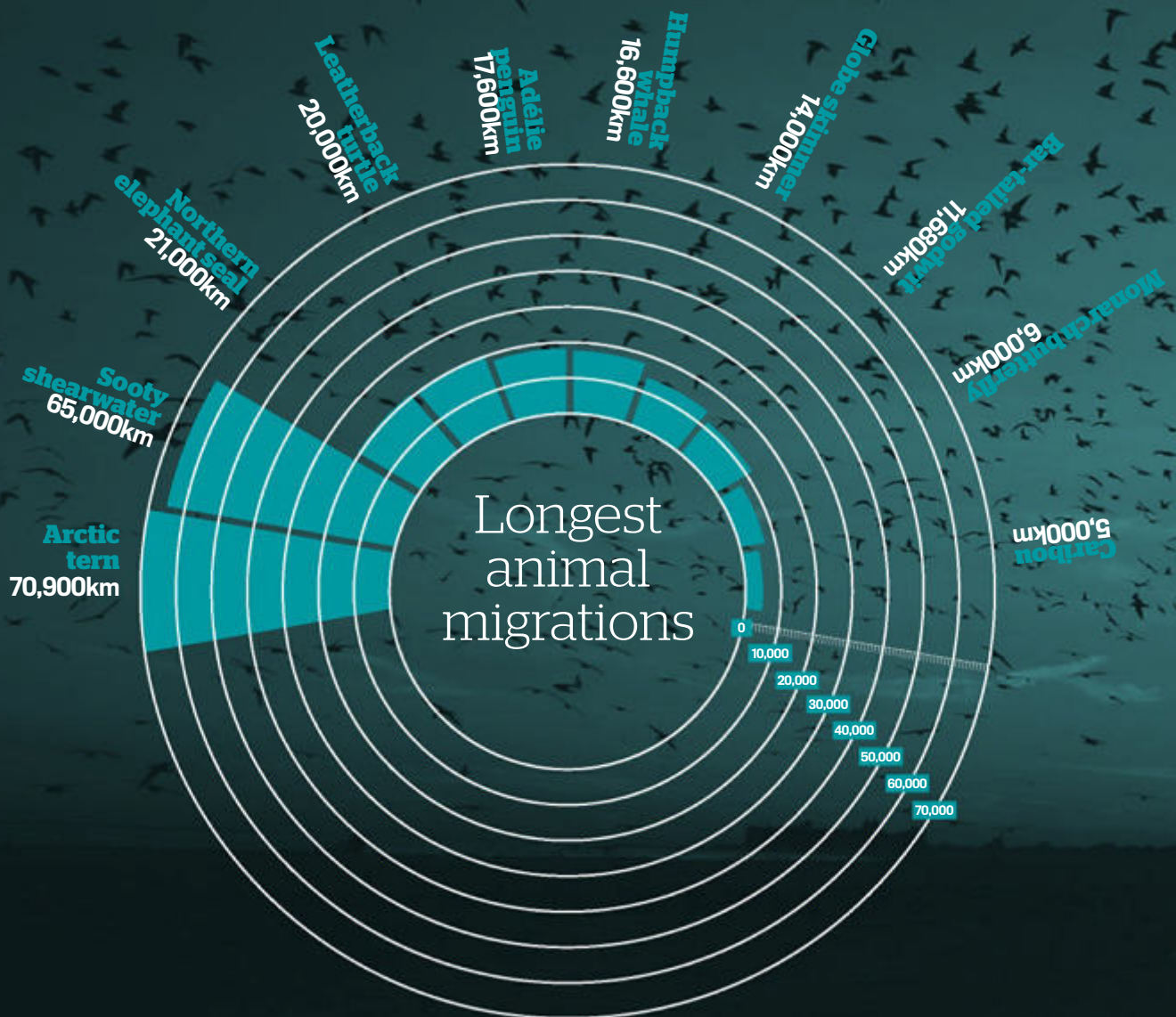
01

Arctic tern *Sterna paradisaea* 70,900km

This small bird – weighing just over 100g – undertakes an incredible two-way migration each year. In August or September each bird leaves its breeding grounds in Greenland and heads south, tracing the coast of either Africa or South America and feeding in the Weddell Sea for four or five months before returning to the Arctic for the northern summer.

DID YOU KNOW?

The bar-tailed godwit fuels its epic migration by digesting part of its own intestine during the long flight



02

Sooty shearwater*Puffinus griseus*
65,000km

These birds follow circular migration routes around the Atlantic and Pacific.

03

Northern elephant seal*Mirounga angustirostris*
21,000km

These mammals swim between Californian and Mexican beaches.

04

Leatherback turtle*Dermochelys coriacea*
20,000km

One tagged turtle swam from Indonesia to the USA across the Pacific.

05

Adélie penguin*Pygoscelis adeliae*
17,600km

Adélis follow the ice edge from breeding colonies to winter feeding grounds.

06

Humpback whale*Megaptera novaeangliae*
16,600km

The mammal with the longest journey swims from Arctic to tropical waters.

07

Globe skimmer*Pantala flavescens*
14,000km+

Evidence suggests that this dragonfly migrates from India to southern Africa.

08

Bar-tailed godwit*Limosa lapponica*
11,680km

This bird flies non-stop from Alaska to New Zealand in just eight days.

09

Monarch butterfly*Danaus plexippus*
6,000km

The migration between USA and Mexico takes three or four generations to complete.

10

Caribou*Rangifer tarandus*
5,000km

Some herds range across Arctic Canada in the longest migration of any terrestrial mammal.

Leatherback turtles migrate across and around the Pacific Ocean



Monarch butterflies migrate from the eastern USA to winter in Mexico's Sierra Madre mountains



10 ANIMAL SUPER-SENSES



Mantis shrimp
Odontodactylus spp.
Technicolour vision

These remarkable stomatopods utilise no fewer than eight colour channels.



Star-nosed mole
Condylura cristata
Super-sensitive nose

Eleven pairs of snout rays equipped with 25,000 Eimer's organs detect prey.



Atlantic salmon
Salmo salar
Sharp smell
Salmon use their sense of smell, 1,000 times more powerful than a dog's, to navigate across the ocean to natal rivers.



Yellow bullhead
Ictalurus natalis
Turbo taste
Some species of catfish boast up to 175,000 taste-sensitive cells all over their bodies.



Four-eyed fish
Anableps spp.
Double vision
With each eye divided into two parts, this fish can see underwater and above the surface at the same time.



Pit viper
Crotalinae
Infrared sensors
Heat-sensing pit organs on their heads allow these snakes to detect infrared for hunting at night.

DID YOU KNOW?

Harbour seals (*Phoca vitulina*) can determine the size of prey fish just by using their whiskers



Bats
Chiroptera
Echolocation
Bats emit sound waves and detect their reflections to build up a visual picture, enabling them to catch tiny insects on the wing.



Platypus
Ornithorhynchus anatinus
Electro-reception
Sensors within the platypus' bill detect the electrical field generated when prey moves.



Spider
Araneae
Vibration
Using special organ called slit sensillae, spiders sense airborne and web-transmitted vibrations, helping them to assess prey.



Pigeon
Columba livia
Magneto-reception
Homing pigeons have the equivalent of an internal GPS system, allowing them to navigate long distances.

10 WEIRD PARASITES



Eye-inflating flatworm
Larvae of the green-banded broodsac fill the eye-stalks of infected snails, making them look (and wriggle) like little caterpillars - luring hunting birds.



Zombie-making wasp
The female emerald cockroach wasp stings a cockroach's brain, then lays an egg on its belly - and the wasp larva devours its host from the inside.



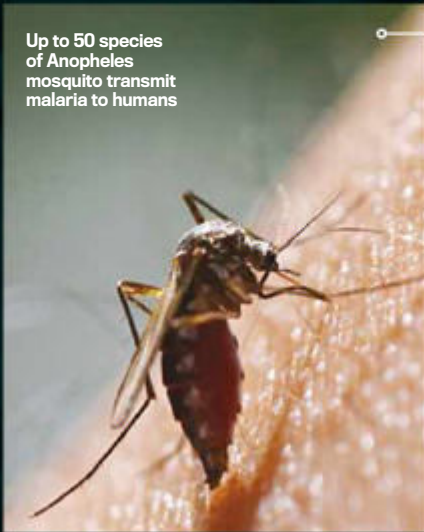
Tongue-eating louse
The sea louse *Cymothoa exigua* feeds on blood from a fish's tongue till it withers away, then attaches itself to the stump to feed on blood and mucus.



Eye worm
The larvae of the nematode worm *Loa loa* infect human eyes, and can be seen and, more horribly, felt as they squirm across the tissue beneath the cornea.

10 DANGEROUS ANIMALS

Up to 50 species of *Anopheles* mosquito transmit malaria to humans



01 Mosquito
Anopheles spp.
Human deaths/year: 2 million
Bites from these insects transmit the plasmodium blood parasites that cause malaria.

02 Asian cobra
Naja naja
Human deaths/year: ≤50,000
Though not India's most venomous snake, this cobra is responsible for the majority of snakebite deaths.

03 Hippopotamus
Hippopotamus amphibius
Human deaths/year: <3,000
Accurate figures are hard to obtain, but hippos are certainly responsible for many deaths every year in Africa.

04 Nile crocodile
Crocodylus niloticus
Human deaths/year: >300
Attacks by this large reptile on people on the water or on riverbanks are relatively frequent in Africa.

05 African elephant
Loxodonta africana
Human deaths/year: ≤300
Elephants probably kill a few hundred people annually - though more than 20,000 elephants are killed by poachers each year.

06 Lion
Panthera leo
Human deaths/year: ≤100
Lion attacks on humans often occur during harvests, but rare outbreaks of mass 'maneating' also occur.

07 Great white shark
Carcharodon carcharias
Human deaths/year: <30
Unprovoked shark attacks on humans are extremely rare - and fatalities even rarer. Great white, tiger and bull sharks are responsible for most.

08 Sloth bear
Melursus ursinus
Human deaths/year: <2
Like other bear species, sloth bears don't predate humans, but chance encounters can result in deaths.

09 Box jellyfish
Chironex fleckeri
Human deaths: At least 60 since 1883
Each of the sea wasp's tentacles is armed with about 5,000 stinging cells.

10 Poison dart frog
Phyllobates terribilis
Human deaths/year: Unknown
Living in the rainforest of Colombia, this frog's skin is coated with enough batrachotoxins to kill at least ten men.

A large male Nile crocodile can grow up to 6m long



Skin-boiling worm

The guinea worm *Dracunculus medinensis* grows up to 1m long in humans, causing a burning pain as it emerges through the skin of legs.

Head-splitting fungus

An ant infected with *Ophiocordyceps unilateralis* climbs to the top of a plant and die. The fungus' fruiting body then bursts from the ant's head.

Sex-change bacteria

Wolbachia are transmitted to their insect hosts' offspring in eggs. To increase dispersal, these bacteria can change hosts' sex from male to female.

Vampire fish

The tiny, eel-like candiru of the Amazon swims into the gills of other fish and feasts on their blood. Reports suggest that it sometimes swims into human orifices.

Mind-control bug

The single-celled parasite *Toxoplasma gondii* eliminates infected rodents' fear of cats - which then easily catch the rodents and are themselves infected.

Crab-castrating barnacle

When a female *Sacculina* barnacle infects a crab, it changes the host's hormones, effectively sterilising it.

Giant tortoises live to extraordinary ages - Galápagos tortoises often reach over 150 years.



10 LONGEST-LIVED VERTEBRATES

01 Aldabra giant tortoise

Aldabrachelys gigantea
Oldest individual recorded:
255 years

Adwaita was a male tortoise reputedly given to Robert Clive in the 18th century. In around 1876 it was transferred to the Alipore Zoo in Kolkata, where it lived until its death in 2006. Adwaita's age cannot be definitively confirmed; the longest-lived reptile for which an age has been verified was Tu'i Malila, a radiated tortoise reputedly given to the Tongan royal family by Captain Cook in 1777, and which died in 1965 at the age of 188.

02

Koi fish
Cyprinus carpio haematopterus
226 years

The oldest-known koi, called Hanako, died in 1977.

03

Bowhead whale
Balaena mysticetus
211 years

200-year-old spears have been found in some bowheads.

04

Tuatara
Sphenodon punctatus
115 years old

Henry, a tuatara in New Zealand, became a father at the age of 111 in 2009.

05

Blue and yellow macaw
Ara ararauna
104 years

Churchill reputedly owned the macaw named Charlie.

06

Asian elephant
Elephas maximus
86 years

Lin Wang or 'Grandpa Lin' died in Taipei Zoo in 2003.

07

Horse
Equus ferus caballus
51 years

The liver chestnut stallion named Shayne died in Essex in 2013.

08

Cow
Bos primigenius
48 years

'Big Bertha' died three months before her 49th birthday.

09

Goldfish
Carassius auratus auratus
43 years

Tish died in North Yorkshire in 1999.

10

Polar bear
Ursus maritimus
42 years

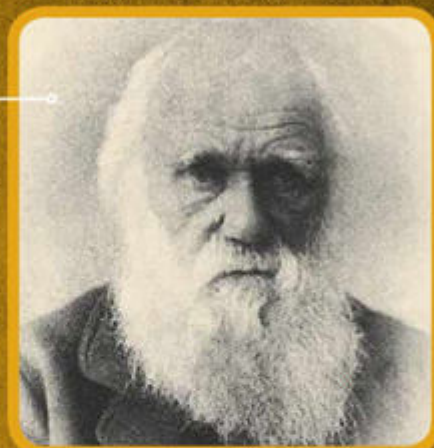
'Debbie' died at Assiniboine Zoo in Winnipeg in 2008.

10 Famous Biologists

Charles Darwin
1809-82

i Proposed the theory of evolution by natural selection

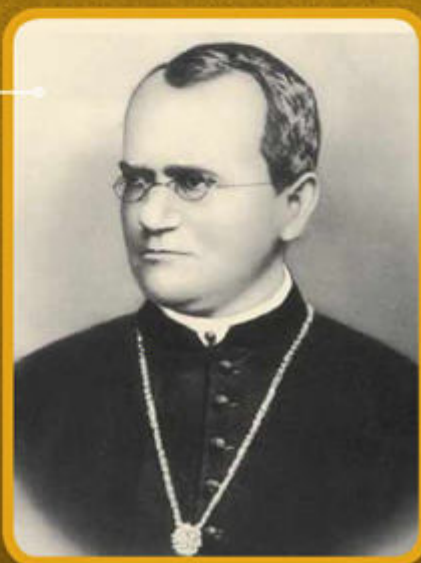
The concept of evolution was well established (though often challenged) before Darwin, but his idea - that differing rates of reproductive success affect how traits are inherited - was revolutionary.



Gregor Mendel
1822-84

i Founder of the science of genetics

Mendel observed that some traits in pea plants are inherited in patterns, and proposed the idea of dominant and recessive traits.



Aristotle
384-322BC

i Classified organisms into a 'ladder of life'

The Greek philosopher pioneered the study of biology. Many of his ideas remained influential till the 19th century.

Claude Bernard
1813-78

i Developed blind testing, discovered homeostasis

Bernard was instrumental in the introduction of blind experiments, vital for producing objective results.

Robert Hooke
1635-1703

i Coined the term 'cell'

In 1667, Hooke identified 'cells' while studying a sliver of cork under a microscope - but he thought only plants had them.

Carl Linnaeus
1707-78

i Created binomial nomenclature for species

This Swedish biologist developed the core of modern taxonomic principles - how we classify organisms - and the binomial naming system that is now universal.

George Cuvier
1769-1832

i Established comparative anatomy and palaeontology

The French researcher compared living animals with fossils, grouped classes of species into phyla, and established extinction as fact.



Alfred Russel Wallace
1823-1913

i Proposed theory of evolution by natural selection

Wallace independently developed a theory of evolution along similar lines to the one that made Darwin's name - the two men had never met before, but their work was published jointly in 1858.

Jane Morris Goodall
1934-present

i Revolutionised study of primate behaviour

Considered to be the world's foremost expert on chimpanzees, Goodall is best known for her 45-year study of wild chimps in Tanzania, which transformed our understanding of social behaviour.

Antonie van Leeuwenhoek
1632-1723

i Observed bacteria under a microscope for the first time

Leeuwenhoek was the first microbiologist, making observations of bacteria and making many improvements to microscopes.

In 1999, NASA's Mars Climate Orbiter disintegrated in the Red Planet's atmosphere - thanks to a blunder in software units



The universe revolves around us

The influential (and groundbreaking) Greco-Roman mathematician and geographer Ptolemy developed an astronomical model in which Earth sat at the centre of the cosmos. His geocentric model went uncorrected until Copernicus proposed his heliocentric theory in 1543 - nearly 1,500 years later.

Fire comes from phlogiston

In 1667, German alchemist Johann Joachim Becher proposed a theory of combustion claiming the existence of *terra pinguis*, an element released when flammable objects are ignited. The substance was later dubbed phlogiston by Georg Ernst Stahl - and, of course, does not exist.

The universe is infinite

Eminent - and controversial - astrophysicist Fred Hoyle posited a 'steady state' theory, suggesting that the universe has existed and will continue to exist forever. In 1949, Hoyle derisively coined the phrase 'big bang' to describe the alternative theory that he continued to deride till his death in 2001.

Energy from cold fusion

In 1989, electrochemists Stanley Pons and Martin Fleischmann announced that they had detected a nuclear reaction at near room temperature - 'cold fusion', a holy grail for the production of cheap and abundant supply of energy. Nobody has since succeeded in reproducing their results.

SCIENCE



Research into the nuts and bolts of the universe makes for riveting reading - from quarks and string theory to landmark breakthroughs (and mistakes), eccentric experiments and dinosaur discoveries

10 BIG BLUNDERS & FALSE CLAIMS

Mars mission malfunction

NASA spent \$327 million launching the Mars Climate Orbiter, which reached the red planet on 23 September 1999 - only to be lost in the Martian atmosphere. A navigation malfunction in its navigation systems was discovered to be the result of a basic error: the orbiter had been engineered using imperial measurements, but was guided using technology that followed the metric system.

DNA is a triple helix

American scientist Linus Pauling was a Nobel-winning chemist - but erred in 1953 when suggesting that DNA has a triple helix structure. Later that year, Francis Watson and James Crick discovered that DNA forms a double helix.

Creation of killer bees

Biologist Warwick Kerr began crossbreeding European and African bees near São Paulo in 1956, in an attempt to develop a species more suited to Brazil's tropical climate. The resulting Africanised bees - aka killer bees, aggressive and prone to swarming - escaped and spread northward as far as the USA.

Travel faster than light

In 2011 the established laws of physics appeared to have been broken when an Italian lab claimed to have witnessed neutrinos travelling faster than the speed of light. Not so. It transpired that the GPS equipment used to track the neutrinos hadn't been hooked up properly.

The cosmological constant

Einstein, believing that the universe was static, introduced a cosmological constant to his general theory of relativity to explain how gravity was thwarted in preventing expansion. When it was discovered that the universe is expanding, he renounced the constant, calling it his 'greatest blunder'. almost the speed of light.

The Earth is young

British scientist Sir William Thomson, 1st Baron Kelvin, is best known for determining the value of the lowest possible temperature (absolute zero, or -273.15°C). But he also used the idea that the Earth is gradually cooling to estimate its age. In 1897 he announced that the Earth was 20-40 million years old. We now know that it's about 4.5 billion years old.

THE 10 MOST EXPENSIVE EXPERIMENTS

\$150
billion

01

International Space Station (£92 billion)

Weighing nearly 420 tonnes and floating 370km above the Earth, the ISS has been continuously occupied by astronauts from various countries since the first crew docked on 2 November 2000.

\$20.6
billion

02

International Thermo-nuclear Experimental Reactor (£12.3 billion)

In 2010 construction began in France on what will become the world's largest tokamak fusion device - a magnetically confined core in which fuel will be heated to temperatures greater than 150,000,000°C.

\$8
billion

03

James Webb Space Telescope (£4.9 billion)

Scheduled to launch in 2018, this telescope - a NASA project with input from the European and Canadian Space Agencies - will investigate how galaxies form by peering out to the farthest reaches of space.



\$6.65
billion

04

International Linear Collider (£4.1 billion)

A planned particle accelerator even bigger than the Large Hadron Collider, the ILC will use a straight path rather than a circular one to measure particle collisions more accurately. Sites in Europe, the USA and Japan are currently being considered, with construction due to begin by 2016.

\$3.26
billion

06

Cassini-Huygens Spacecraft (£2 billion)

Launched in 1997, the Cassini orbiter entered Saturn's orbit in 2004, at which point the Huygens lander probe separated to investigate the ringed planet's largest moon, Titan.



\$3.1
billion

07

Envisat (£1.9 billion)

Launched aboard an Ariane 5 rocket from the European Space Agency's facility in French Guiana in 2002, Envisat spent 10 years in orbit monitoring signs of environmental impact and climate change on Earth's atmosphere, oceans, land and ice. Ground control lost contact with the satellite in 2012.

\$2.7
billion

08

Human Genome Project (£1.65 billion)

Work to map the entire human genome began in 1990; it had a budget of \$3 billion and was expected to take 15 years - but was completed two years early and under budget.

\$2.5
billion

09

Curiosity Rover (£1.5 billion)

This car-sized robotic rover was designed to investigate whether life could ever have existed on Mars. Its original two-year mission was extended indefinitely at the end of 2012, and it continues to explore the Gale crater.

It's hoped the International Linear Collider will help explore the 'Terascale'

\$6.4
billion

05

Large Hadron Collider (£3.84 billion)

The 20 member states of CERN (Conseil Européen pour la Recherche Nucléaire - the European Council for Nuclear Research) picked up most of the cost of the 27km-circumference tunnel and equipment, with significant contributions coming from an additional six observer nations.

\$2
billion

10

Super-conducting Super Collider (£1.2 billion)

Construction on a particle accelerator with an 87km-circumference ring in Texas was halted in 1983 - but not until after nearly half of the \$4.4bn budget had been spent.



Seattle Kingdome Demolition

When: 26 March 2000

Holding up to 66,000 sports fans in its 19,821 million m³ capacity, this stadium became the largest building to be demolished by explosives when it was destroyed in 2000.

Heligoland explosion

When: 18 April 1947

The Royal Navy tried - and failed - to blow up a whole North Sea island and the huge German naval base it carried by detonating around 4,000 tonnes of explosives, one of the world's biggest-ever single detonations. Despite that, the island remained intact.



Mont Blanc

When: 6 December 1917

This French ship was carrying over 2,400 tonnes of explosives when it collided with another vessel off the coast of Nova Scotia, Canada. The *Mont Blanc* was approaching Halifax when the resulting fire caused a massive explosion, levelling 2.5km² of the town and shattering windows 100km away.

Nedelin Catastrophe

When: 24 October 1960

A Russian R-16 intercontinental ballistic missile was being tested when it burst into flames on its launchpad at the Baikonur test range - igniting its tanks that were filled with a toxic fuel mixture called Devil's Venom, and creating a fireball that killed dozens of people.



Buncefield Complex

When: 11 December 2005

The explosion caused when the first of 20 tanks in Britain's fifth-largest oil storage depot blew up was heard 200km away. The British Geological Survey measured the event at 2.4 on the Richter Scale.

Chicxulub Impact

When: 65 million years ago

The Chicxulub crater in Mexico, a staggering 180km wide, was created when a 10km-wide meteorite crashed into Earth. The impact is believed to have been a major contributing factor in the extinction of the dinosaurs.

Mt Toba

When: 75,000 years ago

When the supervolcano Mt Toba erupted, it launched at least 2,800km³ of magma and ash into the atmosphere, causing a six-year volcanic winter and possibly kick-starting an ice age. The resulting crater holds the world's largest volcanic lake.

MOAB

When: 11 March 2003

The USA claims that its Massive Ordnance Air Burst (MOAB) device, containing 9 tonnes of explosive material, is the biggest non-nuclear bomb in the world. The first test detonation occurred in 2003; it is yet to be used in combat, but could destroy tanks and buildings within a radius of several hundred metres.

AN602 'Tsar Bomba'

When: 30 October 1961

This Russian 58-megatonne nuclear weapon, the most powerful ever detonated, was tested over the Arctic. It exploded with more than 4,800 times the energy of the atomic bomb dropped on Hiroshima; the shockwaves travelled around the world three times.

Universe I, Part II

When: 15 July 1988

The world's largest firecracker burst over Hokkaido, Japan during the 1988 Lake Toya Firework Festival. The 700kg shell was moved into position on a floating platform before being ignited, creating a five-colour pyrotechnic display 1.2km across.

10 SCIENTISTS WHO EXPERIMENTED ON THEMSELVES

Max Joseph von Pettenkofer 1818-1901

In 1892, this Bavarian hygienist drank the diarrhoea of a cholera-stricken man in an attempt to demonstrate that the microbes became harmful only after incubating in the ground. He discovered that he was wrong.

William J Harrington 1923-92

The American researcher in autoimmune disorders transfused blood from a patient with idiopathic thrombocytopenic purpura into himself, showing that the condition causes the body to destroy blood platelets.

Horace Wells 1815-48

An American dentist in Connecticut, Wells pioneered the use of nitrous oxide (laughing gas) in dentistry by having one of his own teeth extracted while under anaesthesia.



John Scott Haldane 1860-1936

This Scottish physiologist repeatedly used himself as a guinea pig, testing the effects of breathing various mixes of air and gases. His son Jack was also often involved.

Pierre Curie 1859-1906

To observe the effects of radium on skin, the French scientist strapped a piece to his arm; the resulting burn prompted the idea that radioactive material could be used to treat diseased tissue such as tumours.

Nicolae Minovici 1868-1941

To better understand the experience and effects of hanging, this Romanian forensic scientist hanged himself on several occasions - with assistants on hand to release him.

Barry Marshall 1951-present

The Australian doctor drank a culture of the microbe *Helicobacter pylori* to prove that the bacterium, not stress or spicy food, is responsible for causing stomach ulcers.



John Paul Stapp 1910-99

The American researcher made a huge contribution to air-crash safety by testing the effects of rapid deceleration on the human body, strapping himself to a rocket sled braking rapidly from up to 1,000km/h.



Werner Forssmann 1904-79

The procedure for cardiac catheterisation was developed by this German doctor in 1929, when he threaded a thin rubber tube through a vein in his left arm and into his heart.



Lazzaro Spallanzani 1729-99

This Italian priest swallowed various items, including bones contained in small cloth bags or perforated wooden tubes, to test how stomach secretions help digest food.



10 KEY ACCIDENTAL DISCOVERIES

X-rays

Discovered by: Wilhelm Röntgen
When: 1895

This German physicist studying the emission of cathode rays in a darkened room noticed a fluorescent glow on a screen coated with barium platinocyanide. He reasoned that the glow was caused by the emission of a new type of invisible ray, which he dubbed X-rays.



Vaseline

Discovered by: Robert Chesebrough
When: 1859

Workers on the oil fields of Titusville, Pennsylvania, disliked the black, sticky gunk they called 'rod wax' that formed on the rigs as a byproduct of the oil extraction - but noticed that it helped heal cuts and burns. The young chemist Chesebrough refined some of the rod wax to create the white gel he called Vaseline.

Super Glue

Discovered by: Harry Coover
When: 1942 (and again in 1951)

A research team noticed the incredible adhesive qualities of cyanoacrylates while investigating materials for clear plastic gun sights. Nearly a decade earlier, Harry Coover, recognised their commercial potential as glue.



Teflon

Discovered by: Roy J Plunkett
When: 1938

This US chemist was trying to retrieve tetrafluoroethylene from a cylinder when he found a white powder that was heat resistant, inert and had low surface friction.

Radio astronomy

Discovered by: Karl Jansky
When: 1932

Jansky was investigating static interfering with radio voice transmissions when he identified radiation coming from the centre of the Milky Way.

DID YOU KNOW?

As well as stopping food from sticking to your saucepan, PTFE (Teflon) coats armour-piercing bullets

Saccharin

Discovered by: Constantin Fahlberg and Ira Remsen
When: 1878

After experimenting with sulfobenzoic acids, Russian chemist Constantin Fahlberg returned home for dinner - and noticed a sweet taste on his food, transferred from his hands. He rushed back to the lab and tasted vessels until he found the source of the sweetness, identifying a beaker in which benzoic sulfonide had been produced.

Penicillin

Discovered by: Alexander Fleming
When: 1928

Noticing that *Penicillium* mould growing in cultures of *Staphylococcus* destroyed the bacterial colonies, Fleming identified a substance released by the fungus, which he called penicillin, as the bactericide.



Microwaves for cooking

Discovered by: Percy Spencer
When: 1945

While working for American defence contractor Raytheon, Spencer stood in front of a magnetron with a chocolate bar in his pocket. Noticing that the chocolate melted, Spencer tested the waves again with popcorn - and recognised the cooking potential. Two years later, Raytheon launched the first commercial microwave oven.

Vulcanised rubber

Discovered by: Charles Goodyear
When: 1839

Legend has it that Goodyear spilled a rubber-sulphur powder on a hot stove while brushing his hands. The rubber reacted with the sulphur, a process he termed vulcanisation.



Viagra

Discovered by: Ian Osterloh, Chris Wayman and team
When: early 1990s

Among potential treatments for angina tested by Pfizer scientists was sildenafil citrate, then known simply as UK-92480. Male volunteers reported experiencing increased erections several days after the initial dose - and the research team spotted the potential of the drug later named Viagra.

10 BREAKTHROUGHS IN GEOLOGY

Deep time

Who: Aristotle

When: 4th century BC

The Greek philosopher recognised that the Earth changes at an indiscernably slow rate, writing: "the distribution of land and sea in particular regions does not endure throughout all time" - a concept dubbed 'deep time'.

Stratification of the Earth's crust

Who: Abraham Werner

When: 1774

As the creationist views of early geologists softened, German geologist Werner proposed a system of classification of rocks and divided them into five chronological formations.

Geomorphology

Who: Shen Kuo

When: 11th century AD

Chinese scientist Shen Kuo (AD 1031-95) made observations of marine fossil shells in mountains far from the ocean, and proposed that the rocks were once on a seashore. He theorised that land formed from uplift and silt deposits, and is gradually eroded.

Continental drift

Who: Abraham Ortelius

When: 1596

Though Alfred Wegener is credited with the idea of continental drift - land splitting from an ancient single mass, a hypothesis he presented in 1912 - over three centuries earlier the Flemish geographer Ortelius had suggested that the Americas had once been connected to Europe and Asia.

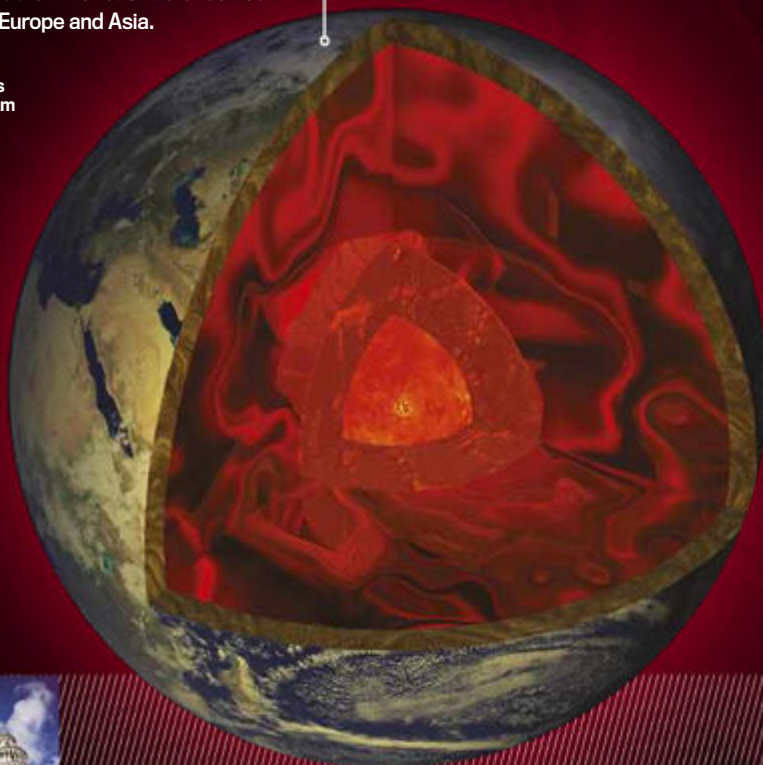
The edge of the Earth's core sits at about 2,900km beneath the surface.

The Earth's core

Who: Richard Dixon Oldham

When: 1906

Oldham analysed the speed at which earthquake waves travel through the Earth, and noticed that the speed drops markedly towards the centre - thence deducing the existence of a core of a different density.



10 CRUCIAL PHYSICS THEORIES

Falling objects of different sizes accelerate at the same rate

Who: Galileo Galilei

When: 1589

To disprove Aristotle's theory of gravity, Galileo dropped two balls of different weights from the top of Italy's Leaning Tower of Pisa.

Everything is composed of atoms

Who: Leucippus and Democritus

When: 5th century BC

Atomism proposes that everything is composed of an infinite variety of indestructible, immutable 'atoms' that collide or link up to form clusters.

Atoms are composed of smaller particles

Who: Joseph John Thomson

When: 1897

By demonstrating that cathode rays are composed of negatively charged particles, Thomson effectively found the electron - the first of the subatomic particles to be discovered.

Every event has a natural cause

Who: Thales

When: c580BC

Greek philosopher Thales attempted to explain natural phenomena without reference to mythology. He was among the first to try to identify a substance from which all things are composed (water, he thought).

The strata of sandstone can be clearly seen at Antelope Canyon, Arizona



Geological strata

Who: Ibn Sina (Avicenna)
When: c AD 1027

In his *Book of Healing*, the great Persian polymath Ibn Sina described the process by which layers of rocks of different hardness – geological strata – are overlaid and eroded at varying rates.

Fossils identifying strata

Who: William Smith
When: c 1799

Known as the 'Father of English Geology', Smith's studies of the rock layers of England led him to propose the Theory of Faunal Succession, stating that fossils of the same age would be found in similar rock strata across the country.

Paleomagnetism

Who: Stanley Keith Runcorn
When: 1940s and 1950s

The British geophysicist Runcorn established the study of residual magnetisation in ancient rocks. His work demonstrated reversals of Earth's magnetic field, and provided evidence for continental drift.

Accurate age of the Earth

Who: Clair Cameron Patterson
When: 1953

The American geochemist used lead isotopic data from the Canyon Diablo meteorite to calculate the Earth's age to within 70 million years. His figure, 4.55 billion years, has remained essentially unchallenged since.

DID YOU KNOW?

At Silfra in Iceland (pictured right) you can snorkel between the European and North American continental plates



Plate tectonics

Who: John Tuzo Wilson
When: 1965

The concepts involved in explaining Wegener's theory of continental drift had been developed and refined with the discovery of mid-ocean ridge spreading and the study of paleomagnetism, but Tuzo Wilson added the final elements to complete the picture of massive moving plates.



Buoyant force equals displaced fluid weight

Who: Archimedes
When: c 250BC

Archimedes' principle states that: "Any object, wholly or partially immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the object."

Atoms of an element are identical in size and mass

Who: John Dalton
When: 1803

Our modern concept of atoms is based on a lecture in which Dalton proposed that matter is made of indestructible atoms, and that all atoms of the same element are identical.

Energy can't be created or destroyed

Who: Julius von Mayer
When: 1842

German scientist Julius von Mayer established the law of the conservation of energy within a closed system (though it can be converted between different types – for example, between heat and kinetic).



Objects move at a constant velocity unless acted on by external force

Who: Isaac Newton
When: 1687

Newton's three laws of motion, including this first law, form the foundation of classical mechanics as we now understand it.

Mass has an associated energy

Who: Albert Einstein
When: 1905

Arising from his theory of special relativity, Einstein's most famous equation ($E=mc^2$: energy equals mass times speed of light squared) shows that the mass of an object is a measure of its energy.

Hadrons are composed of quarks

Who: Murray Gell-Mann and George Zweig
When: 1964

Hadrons (subatomic particles including neutrons and protons that comprise atoms) are themselves composed of smaller particles called quarks.

10 INFLUENTIAL PALAEOONTOLOGISTS

Luis Alvarez
1911-88
Tackled the mystery behind dinosaur extinction

Though primarily a physicist, Alvarez became interested in prehistory when his son Walter, a geologist, studied limestone layers in Italy. Together they compiled evidence that a massive meteor impact caused dinosaurs to die out in a mass extinction event.

Jack Horner
1946-present
Provided evidence that dinosaurs cared for their young

The American's discoveries include several *T. rex* fossils and his research focuses on dinosaur growth. But his most significant discovery was a colonial nesting site of a creature he named *Maiasaura*, showing that some species cared for their young.

Barnum Brown
1873-1963
Discovered first remains of *Tyrannosaurus rex*

Brown was one of the most famous and colourful characters in the fossil-hunting world. In 1902, at the Hell Creek Formation of Southeastern Montana, he discovered and excavated a fossil of the species that became known as *Tyrannosaurus rex*.



Edwin H. Colbert
1905-2011
Helped prove continental drift

During his career, the American discovered numerous species of dinosaur. But his biggest breakthrough came when he excavated a fossil *Lystrosaurus*, a genus previously found in Africa - showing that the two continents were once joined in a giant land mass.

Edward Drinker Cope
1840-97
Named 1,000 fossil vertebrates

Cope is famed for his intense rivalry known as the 'Bone Wars', a two-decade fossil-finding competition with Othniel C. Marsh. The 'Wars' led to the discovery of more than 120 new species of dinosaurs across the USA.



Dong Zhiming
1937-present
Excavated revelations from the mid-Jurassic

China's leading palaeontologist discovered the fossil beds of the Dashanpu Formation in Sichuan, yielding new species from the middle Jurassic (around 165 million years ago), a little-represented period. He has also named more than 20 genera of dinosaurs.

10 GAME-CHANGING FOSSIL FINDS



Megalosaurus
Discovered: 1676
Where: Oxfordshire
Lived: Jurassic (201-145 million years ago)

A fossilised femur from this carnivore (left) was discovered in 1676, but it was nearly 150 years later that William Buckland and colleagues named the 'huge lizard' - and recognised it as the first-known dinosaur.

Marine fossils
Discovered: 6th century BC
Where: Greece
Lived: various periods

The Greek philosopher Xenophanes reasoned that the fossils of marine creatures found on land were evidence of sea covering the earth in previous eras.

Mosasaurus
Discovered: 1764
Where: Maastricht, Netherlands
Lived: Cretaceous (around 70-65 million years ago)

This aquatic reptile was the first to be identified as an extinct species, by Georges Cuvier, and the first genus of such an animal to be named, in 1822 by William Conybeare.

Iguanodon
Discovered: c1821
Where: Sussex
Lived: Early Cretaceous (around 125 million years ago)

One of three genera included in the original classification of dinosauria, the first fossils of this 10m-long herbivore - discovered in the early 1820s by Gideon Mantell - fuelled a fiery debate about evolution and whether prehistoric reptiles had actually existed.

Robert Bakker 1945-present Developed a theory of 'warm-blooded' dinosaurs

A major player in the 'dinosaur renaissance', transforming our understanding of the anatomy and behaviour of prehistoric beasts, Bakker postulated that dinosaurs were endothermic, fast and adaptable. He also advised on the film *Jurassic Park*.



John Ostrom 1928-2005 Proposed that birds are descended from dinosaurs

In the 1960s, this American scientist observed that dinosaur fossils demonstrate features more like those of birds than of lizards - though it wasn't till the discovery of feathered dinosaurs in China decades later that his ideas were accepted.

Mary Anning 1799-1847 Discovered plesiosaurs

Rare among palaeontologists - and not accorded the acclaim she deserved till well after her death - Anning discovered numerous important fossils in the rocks of Dorset's 'Jurassic Coast', including the first plesiosaur ever excavated.



Patricia Vickers-Rich 1944-present Discovered dinosaurs that survived the cold

An American researching finds in Australia, Vickers-Rich excavated the important site called Dinosaur Cove on Australia's southern coast, discovering species that lived during the cretaceous period, a time when near-Antarctic conditions prevailed.

DID YOU KNOW?

Fossils identified as 'dragon bones' were described by 4th-century Chinese historian Chang Qu

Archaeopteryx

Discovered: around 1861

Where: Solnhofen, Germany

Lived: Late Jurassic (around 150 million years ago)

The 'first bird' was a transitional species linking feathered dinosaurs with modern birds - and its status in this transition is still steeped in controversy.



Thrinaxodon

Discovered: named 1894

Where: South Africa

Lived: Early Triassic (250-245 million years ago)

This low-slung, burrowing carnivore had dog-like teeth and may have sported fur. It's considered to have been a precursor of modern mammals.

Tiktaalik

Discovered: 2004

Where: Ellesmere Island, Canada

Lived: Late Devonian (around 375 million years ago)

Many features of this lobe-finned fish are similar to those of four-legged animals - this creature and its relatives may have been the ancestors of most modern terrestrial animals.

Diplodocus

Discovered: 1877

Where: Colorado, USA

Lived: Late Jurassic (155-145 million years ago)

This monstrous herbivore, stretching to 33m in length, was the first near-complete fossil of a giant sauropod to be discovered.

Ambulocetus

Discovered: 1993

Where: Pakistan

Lived: Early Eocene (50-48 million years ago)

In form a little like a mammalian crocodile, *Ambulocetus* was adapted for both aquatic and terrestrial life - it could swim as well as walk - and was probably a forerunner of modern whales.

Amphistium

Discovered: 18th century

Where: Northern Italy

Lived: 50 million years ago

This transitional genus of flatfish had one eye on top of its head. As researcher Matt Friedman realised in 2008, it was probably the ancestor of modern fish such as flounder, halibut and sole, which have both eyes on one side of the head.

10 BREAKTHROUGHS IN BIOLOGY

Cell division

Who: Robert Remak

When: 1855

By staining a cell's membrane, Remak was able to prove that new cells are formed by the division of existing cells. He also surmised that tumours grow and are spread in the same manner.



Cell biology

Who: Henri Dutrochet

When: Early 19th century

The French physiologist pioneered the study of cells as the key units of function in life, and suggested that basic processes of life are similar across all organisms.

By hardening the cell membrane, Remak was able to observe cell division

Homeostasis

Who: Claude Bernard

When: 1854

Bernard stated that "all the vital mechanisms, varied as they are, have only one object: that of preserving constant the conditions of life." This encapsulates the concept of homeostasis - the maintenance of a constant internal environment, key to most forms of life.

Osmosis

Who: Jean-Antoine Nollet

When: 1748

Nollet was the first person to document osmosis - variations in the concentrations of dissolved substances causing movement of the solvent (for example, water) - a key process in biology that explains, for example, how plants take up water from the soil.

Theory of evolution by natural selection

Who: Charles Darwin and Alfred Russel Wallace

When: 1858

Darwin and Wallace each independently conceived the theory that species develop through a process of natural selection.

Inheritance of acquired traits

Who: Jean-Baptiste Lamarck

When: 1801

Lamarck proposed that characteristics acquired by an organism can be passed on to offspring. Long considered inaccurate, modern ideas of epigenetics endorse a form of this type of inheritance may occur.

Biogenesis

Who: Louis Pasteur

When: 1861

Pasteur showed that the growth of bacteria from fermentation was a result of biogenesis - and extrapolated that all life originates from an organism similar to itself, rather than non-living material, as was earlier believed.

Genetic inheritance

Who: Gregor Mendel

When: 1865

By studying pea plants, Mendel discovered that inheritance of many traits, such as height, could be explained through simple rules - resulting in the concept of dominant and recessive genes.

Food chain

Who: Al-Jahiz

When: 9th century AD

The idea that all organisms are dependent on others, together forming a vast web encompassing all species, was proposed by the Arabic writer Al-Jahiz.

Chromosomes

Who: Theodor Boveri and Walter Sutton

When: 1902

The independent work of these two biologists led to the conclusion that pairs of chromosomes, found in all dividing cells, carry the information by which genetic traits are inherited.

560
billion tonnes - the estimated total biomass of animals and plants on Earth (excluding bacteria)

10 Famous Mathematicians

Archimedes

c 287-c 212BC

Approximated pi

Using a method of 'exhaustion', the mathematician - born in Syracuse, Italy - was able to calculate a remarkably accurate approximation of pi.

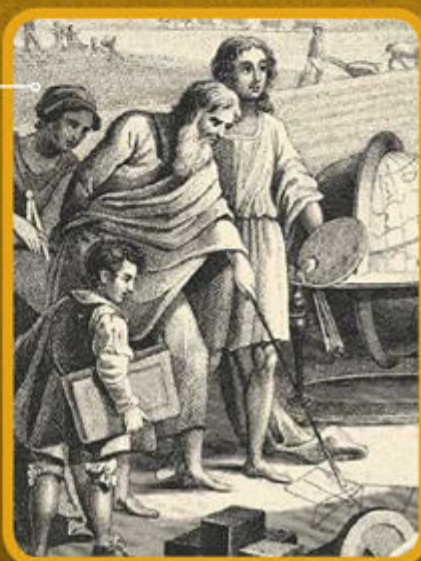


Pythagoras

570-495BC

Eponymous theorem

The Greek mathematician calculated the square of the hypotenuse on a right-angled triangle equals the squares of the other two sides.



Andrew Wiles

1953-present

Proved Fermat's Last Theorem

In 1993 the Briton presented his proof of the 'unprovable' theorem.

Gottfried Wilhelm Leibniz

1646-1716

Developed infinitesimal calculus

The mathematical notation of calculus has been widely adopted.

Fibonacci

1170-1250

Born in Italy

Introduced Arabic numerals

In 1202 Leonardo Pisano Bigollo introduced to Europe the Hindu-Arabic numeral system, is based on numbers 0-9.

Rene Descartes

1596-1650

Developed analytical geometry

The French mathematician formulated the convention of representing unknowns in equations by using x, y and z.

Leonhard Euler

1707-83

Established the subject of pure mathematics

Working across almost all areas of maths, Euler's works fill some 80 quarto volumes. He devised many mathematical notations, including the widely used $f(x)$.



Euclid

c 300BC

Formalised principles of geometry

Euclid's *Elements* became the main textbook for teaching geometry until the late 20th century.

Carl Friedrich Gauss

1777-1855

Contributions to number theory, geometry and probability theory

Gauss' first discovery was that a regular 17-sided polygon could be constructed with just a ruler and compass.

Hypatia

Around AD 350-415

Taught the works of Plato and Aristotle to all comers

A charismatic leader, this Greek-Egyptian woman was the first well-documented female mathematician and the head of the Platonist school at Alexandria.

As head of the British Empire, Queen Victoria was also Empress of India





HISTORY



The evolution of civilisation and science through five and a half thousand years of recorded history - and even before - yields a treasure trove of astonishing facts, mysteries and hoaxes

THE 10 LARGEST EMPIRES

01

British Empire

Worldwide
36.2 million km² (in 1921)

Empire existed: 1497-1997

At the height of its global power in the early 1920s, Britain ruled over more than 450 million people across several continents - this represented a fifth of the world's population at the time. Indeed, such was its geographical spread that it prompted the phrase "the empire on which the sun never sets" - that is, it was always daylight in at least one of its territories.

02

Mongol Empire

Central Asia
33 million km²
(in 1274)
1206-1370

03

Russian Empire

Northern Asia
22.8 million km² (in 1866)
1721-1917

04

Spanish Empire

Central and South America
19.4 million km²
(c 1750)
1492-1898

05

Umayyad Caliphate

North Africa and Middle East
15 million km²
(750)
661-750

06

Qing Dynasty

East Asia
14.7 million km²
(1790)
1644-1912

07

Yuan Dynasty

East Asia
14 million km²
(1310)
1271-1368

08

French Empire

Worldwide
12.3 million km²
(1938)
1534-1980

09

Abbasid Caliphate

North Africa and Middle East
11.1 million km²
(c 850)
750-1258

10

Portuguese Empire

Africa and South America
10.4 million km²
(1815)
1415-1999

1997

This is generally regarded as the year that the curtain finally fell on the British Empire, when Hong Kong returned to Chinese rule

THE 10 LONGEST-REIGNING BRITISH MONARCHS

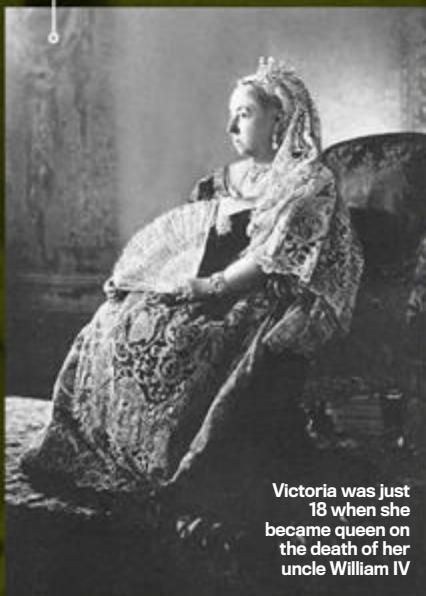
01 Victoria
Reigned: 63 years, 216 days
20 June 1837 until
22 January 1901

02 Elizabeth II
Reigned: 62 years and counting
6 February 1952 to present

03 George III
Reigned: 59 years, 109 days
25 October 1760 until
29 January 1820

04 James VI and I
Reigned (Scotland):
57 years, 246 days
24 July 1567 (Scotland only)
until 27 March 1625

05 Henry III
Reigned: 56 years,
29 days (England only)
19 October 1216 until
16 November 1272



Victoria was just 18 when she became queen on the death of her uncle William IV

Queen Elizabeth on Coronation Day in 1953



THE WORLD'S 10 OLDEST CITIES

01

Jericho
Founded:
c 9000BC

The first settlers were attracted by the numerous springs around the site, now within the Palestinian territories.

02

Byblos
Founded:
c 5000BC

Known as Gubal by the Phoenicians and renamed Byblos by the Greeks, this Lebanese city is possibly the world's oldest continuously inhabited settlement.

03

Aleppo
Founded:
c 4300BC

Founded as Halab, this Syrian city was the capital of the Amorite dynasty of Yamhad.

03

Damascus
Founded:
c 4300BC

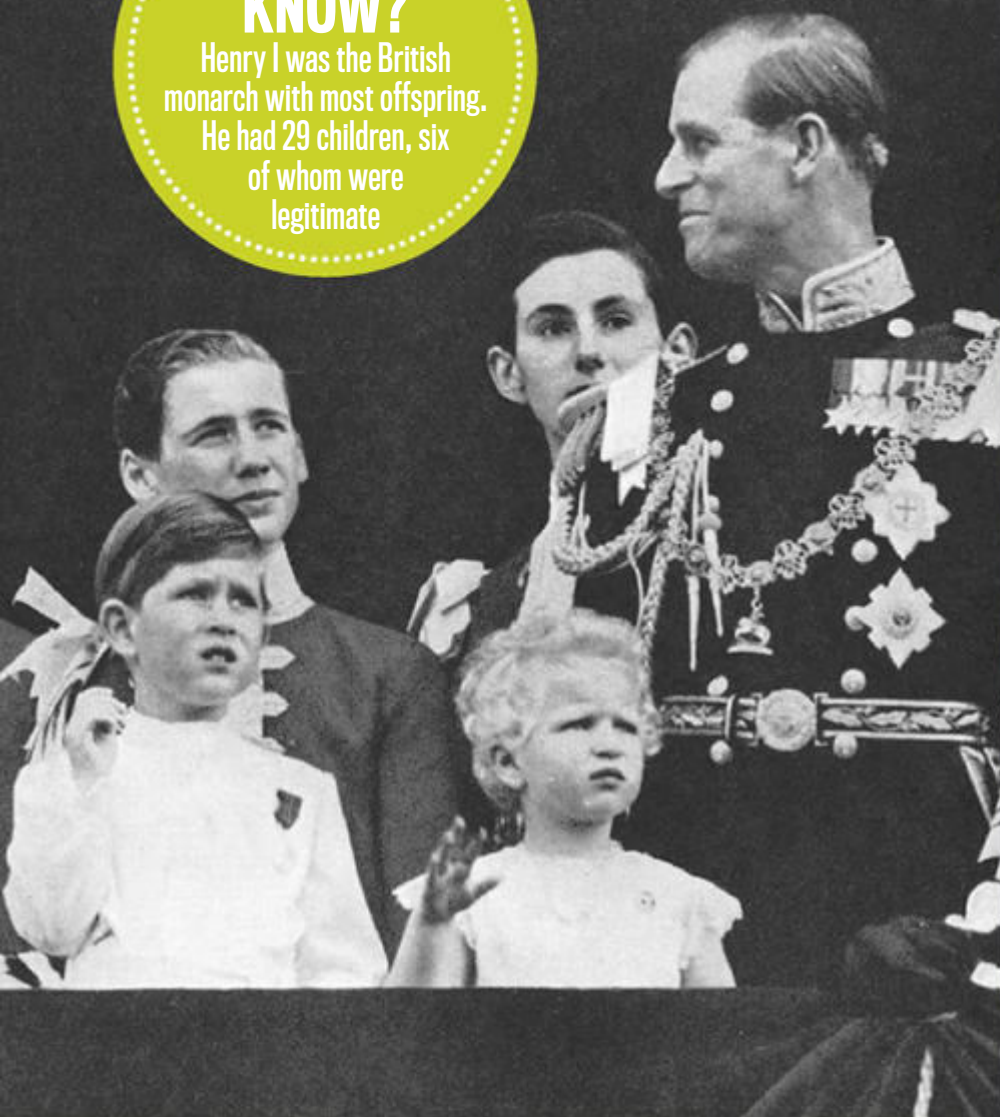
Some argue that the Syrian capital has been inhabited since 10,000BC.





DID YOU KNOW?

Henry I was the British monarch with most offspring. He had 29 children, six of whom were legitimate



- 06 Edward III**
Reigned: 50 years, 147 days (England only)
25 January 1327
until 21 June 1377
- 07 William I**
Reigned: 48 years, 360 days (Scotland only)
9 December 1165 until
4 December 1214
- 08 Elizabeth I**
Reigned: 44 years, 127 days (England only)
17 November 1558
until 24 March 1603
- 09 David II**
Reigned: 41 years, 260 days (Scotland only)
7 June 1329 until
22 February 1371
- 10 Henry VI**
Reigned: 38 years, 185 days (England only)
31 August 1422 until
4 March 1461

* Until 1603, the crowns of England and Scotland were separate. Monarchs since then have reigned over both countries.

05

Shush

Founded:
c 4200BC

Originally called Susa, this Iranian city was the capital of the Elamite Empire.

=06

Faiyum

Founded:
c 4000BC

This Egyptian settlement is located on part of the site of the ancient Crocodilopolis, dedicated to the worship of a sacred crocodile.

=06

Sidon

Founded:
c 4000BC

The base from which the Phoenician empire grew, this Lebanese city was reputedly visited by Jesus, St Paul and Alexander the Great.

=06

Plovdiv

Founded:
4000BC

The discovery of pottery and other everyday objects dating back several thousand years proves that the site of this Bulgarian city was settled in the Neolithic Age.

09

Gaziantep

Founded:
3650BC

This city, now in south-central Turkey near the Syrian border, was founded by the Hittites.

10

Beirut

Founded:
3000BC

The name of the Lebanese capital is derived from the Canaanite word Be'erot or wells. The underground water supply is still used to day.



10 FAMOUS HOAXES

A feathered missing link

Discovered: 1997 **Exposed:** 1999

In 1999, the National Geographic Society trumpeted the discovery, two years earlier, of the remains of a dinosaur covered in bird-like plumage. It was not a missing link, but a forgery created by a Chinese farmer.

Hitler's Diaries

Discovered and exposed: 1983

Historian Hugh Trevor-Roper was left with egg on his face after authenticating documents purporting to be the Nazi leader's diaries. They were actually the handiwork of Konrad Kujau, a notorious German forger.

Piltdown Man

Discovered: 1912 **Exposed:** 1953

A skull and jawbone discovered in Piltdown in East Sussex were relics from a modern man and an orangutan – not a previously unknown form of early human, as amateur archaeologist (and the hoax's perpetrator) Charles Dawson claimed.

The Fiji Mermaid

Publicised and exposed: 1842

The legendary circus impresario PT Barnum toured the US with this 'mummified mermaid' – and had the public fooled. Until, that is, it emerged that the mermaid possessed the withered head of a monkey and the tail of a dried fish.

Alien autopsy

Publicised: early 1990s
Exposed: 1995

The bodies that appeared in film footage claimed to depict an alien autopsy performed after the Roswell UFO incident in 1947 were, in fact, dummies created by Ray Santilli, an entrepreneur from London's Camden Town.

The Cardiff Giant

Discovered and exposed: 1869

A 10ft-tall 'petrified man' excavated by workers in Cardiff, New York, turned out to have been carved out of gypsum by tobaccoist George Hull.



Orson Welles caused panic across the US with his radio broadcast in 1938



Stern journalist Gerd Heidemann presents the alleged diaries of Adolf Hitler to the press in 1983

DID YOU KNOW?

In 1915, British intelligence services discovered that semen made an effective invisible ink

The War Of The Worlds**Perpetrated and exposed:** 1938

Thousands of Americans believed that their country was under attack by aliens when Orson Welles broadcast a radio adaptation of HG Wells' *The War Of The Worlds*.

The Cottingley Fairies**Claimed:** 1917**Exposed:** 1980s

More than 60 years after Edwardian England was enchanted by five pictures showing two young girls, Frances Griffiths and Elsie Wright, surrounded by fairies, the former admitted the photos were hoaxes.

**The Protocols Of The Elders Of Zion****Published:** 1903 **Exposed:** 1921

This anti-Semitic book, purporting to describe a Jewish conspiracy to dominate the world, was disseminated across the globe. It was probably plagiarised by Russian agents from various sources.

Loch Ness Monster photo**Taken:** 1934 **Exposed:** 1990s

Robert Kenneth Wilson's iconic photo seemed to confirm the Loch Ness monster's existence, but later analysis suggested that 'Nessie' was probably being towed.

10 ENDURING HISTORICAL MYTHS

Nero fiddled while Rome burned

The origin of this expression is definitely contentious. Though Nero was known as a musician, the fiddle wasn't invented until 1,500 years after the fire of Rome.

Sir Walter Raleigh laid down his cloak for Elizabeth

The legend of chivalrous Sir Walter laying his cloak over a puddle to keep Queen Elizabeth's feet dry stems from Walter Scott's romantic novel *Kenilworth* of 1821.

Romans deliberately vomited at orgies

The 'vomitorium' was actually the entrance allowing crowds to exit and enter a stadium.

**American Independence was declared on 4 July**

The *Pennsylvania Evening Post* published the news about the resolution declaring independence on 2 July. The actual document called *The Declaration of Independence* was approved on the 4th.

Albert Einstein failed maths at school

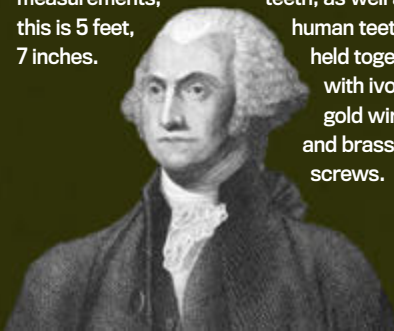
When he saw this claim published, Einstein corrected it: "I never failed in mathematics. Before I was 15, I had mastered differential and integral calculus."

Marco Polo brought pasta to Italy from China

Though wheat noodles probably existed in China for centuries before Polo visited, it's likely pasta (or similar preparations) had arrived in Italy from Arab lands well before the 13th century.

Napoleon was short

The 'little corporal' was actually slightly taller than the average Frenchman of his time - 5 French feet, 2 inches. In English measurements, this is 5 feet, 7 inches.

**George Washington had wooden teeth**

The dentures of the first US president (below) were made of hippopotamus and other animal teeth, as well as human teeth held together with ivory, gold wire and brass screws.

"Let Them Eat Cake"

Marie Antoinette never suggested that the breadless peasants of the 18th century should eat cake. The misattributed quote is from Jean-Jacques Rousseau's autobiography - the 'great princess' would have been only 11 at the time.

Witches were burned at the stake in Salem

Though witch trials were certainly held in the Massachusetts town of Salem, there's no evidence that 'witches' were burned at the stake. Some 20 women were hanged or crushed, and their bodies later burned.

10 ANCIENT ENGINEERING ACHIEVEMENTS



The Colosseum

Where: Rome

Date built:
AD 70-80

It took an estimated 100,000m³ of travertine stone to build the largest amphitheatre in the Roman Empire, accommodating 50,000 spectators.

Saksaywaman

Where: Peru

Date built:
15th century
AD

Scientists still don't know how the Inca transported the massive boulders used to construct this huge walled complex in Cusco.

Aqueduct of Segovia

Where: Spain

Date built:
1st century AD

It may have been constructed by the Romans 2,000 years ago, but this 167-arch masterpiece still carries water from the River Frio to the town of Segovia today.

Great Pyramid of Giza

Where: Egypt

Date built:
c 2500BC

The tallest man-made structure on Earth for 3,800 years, construction of the Pyramid of Khufu took 100,000 workmen up to 20 years.



10 DOOMED EXPEDITIONS

North face of the Eiger

Led by: Toni Kurz and Andreas Hinterstoisser

Date: 1936

Kurz and Hinterstoisser both lost their lives during this famous attempt on the formidable Swiss peak, the former tragically dying from exhaustion just metres from his would-be rescuers.

Polaris Expedition

Led by: Charles Francis Hall

Date: 1871

It wasn't the cold that scuppered Hall's attempt on the North Pole, but arsenic poisoning, suggesting that he may have been murdered by another member of the expedition.

Imperial Trans-Antarctic Expedition

Led by: Ernest Shackleton

Date: 1914-17

Shackleton's attempt on a land crossing of Antarctica ended in disaster when his ship, *Endurance*, became trapped in ice and sank. The story of his epic rescue mission is legendary.



The Donner Party

Led by: The Reed and Donner families

Date: 1846-47

When a party of pioneer families and their employees got trapped in the mountains of the Sierra Nevada, this journey west to California descended into cannibalism.



Attempt to navigate the Northwest Passage

Led by: John Franklin

Date: 1847

Franklin's entire party died of starvation, hypothermia, tuberculosis, lead poisoning and scurvy after being forced to abandon their ice-bound ships.

Stonehenge**Where:**

England

Date built:From
c 2500BC

Our prehistoric ancestors may have transported 82 huge stones more than 200km from the Preseli Mountains of west Wales to this giant astrological observatory.

**Mohenjo-daro****Where:**

Pakistan

Date built:

2600BC

This city boasted thousands of mortared brick buildings, a street plan designed to a grid and sewage systems that wouldn't be matched in many parts of Europe until the 20th century.

Great Wall of China**Where:** China**Date built:**Begun in
c 220BC

At nearly 9,000km long - and, at points, rising to almost 1km above sea level - it's little wonder that the Great Wall of China is arguably the most iconic of all man-made constructions.

**Teotihuacan****Where:**

Mexico

Date built:

100BC-AD 250

This Aztec

metropolis was, for centuries, the largest city in the Americas, and home to the third-tallest pyramid in the world, the Pyramid of the Sun.

Leshan Giant Buddha**Where:** China**Date built:**Begun in
AD 713

It took thousands of workers more than 90 years to complete this, the largest carved stone Buddhist in the world, standing some 71m tall.

Antikythera Mechanism**Where:**

Greece

Date built: 2nd
century BC

Arguably the most complex device from the ancient world, the Antikythera Mechanism is a mechanical 'computer' that tracks the cycles of the solar system.

DID YOU KNOW?

Ferdinand Magellan gave the Pacific Ocean its name. 'Mar pacifico' means 'peaceful sea' in Portuguese

Terra Nova expedition**Led by:** Robert Falcon Scott**Date:** 1912

Five members of Scott's party reached the South Pole - 33 days after their Norwegian rivals led by Roald Amundsen became the first to do so - but all perished on the return journey.

**The search for the city of Z****Led by:** Percy Harrison Fawcett**Date:** 1925

British explorer Fawcett's obsession with finding El Dorado, the legendary 'City of Gold', was to prove his undoing. He disappeared without trace in the Brazilian jungle.

Mount Everest expedition**Led by:** George Mallory and
'Sandy' Irvine**Date:** 1924

Did Mallory and Irvine become the first men to conquer Everest? We'll probably never know for sure - Mallory's body was recovered in 1999, but with no evidence to show whether he had reached the summit.

**Round-the-world flight****Led by:** Amelia Earhart**Date:** 1937

The first woman to fly solo across the Atlantic, intrepid aviator Earhart disappeared somewhere over the Pacific Ocean during her pioneering round-the-world flight. Her body has never been found.

Flying to the North Pole**Led by:** Salomon August Andrée**Date:** 1897

Andrée's mission to fly to the North Pole ended in tragedy when his hydrogen balloon was blown off course. The Swedish engineer and two colleagues died attempting to trek back to civilisation.

THE 10 MOST LETHAL CONFLICTS

01 Second World War
When: 1939-45
Belligerents: More than 30 nations
Death toll: 50-85 million

02 Mongol Conquests
When: 1206-1337
Belligerents: Nations across Asia and eastern Europe
Death toll: 30-60 million

03 Qing Dynasty conquest
When: 1616-62
Belligerents: Qing and Ming dynasties in China
Death toll: 25 million

04 Taiping Rebellion
When: 1850-64
Belligerents: Qing Dynasty, Taiping Heavenly Kingdom, Britain, France, USA
Death toll: At least 20 million

05 An Lushan Rebellion
When: AD 755-763
Belligerents: Tang and Yan dynasties in China
Death toll: 13 million

06 First World War
When: 1914-18
Belligerents: More than 20 nations across the globe
Death toll: At least 10 million

07 Dungan Revolt
When: 1862-77
Belligerents: Qing Empire and Hui Muslims
Death toll: 8-12 million

08 Russian Civil War
When: 1917-22
Belligerents: Red Army, White Army
Death toll: 5-9 million

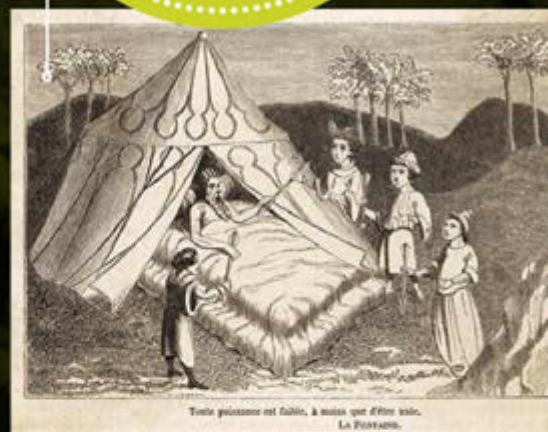
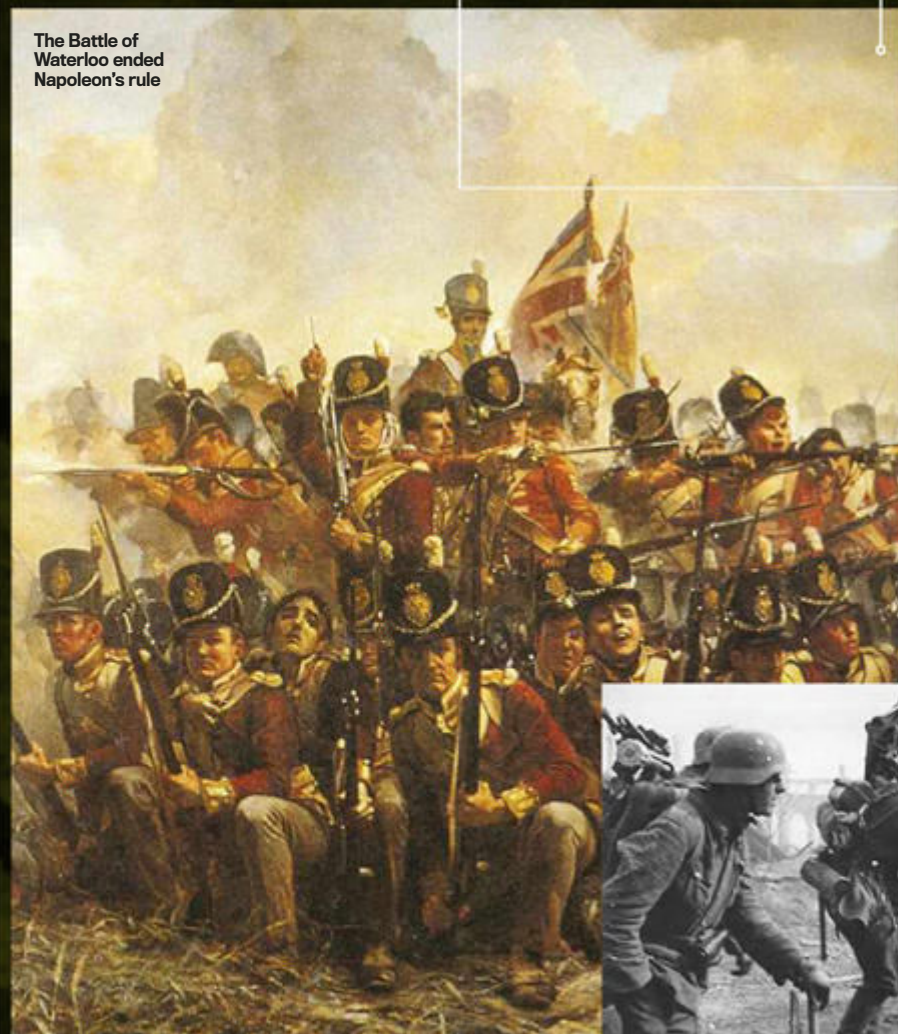
09 Thirty Years' War
When: 1618-48
Belligerents: Protestant and Catholic states across much of Europe
Death toll: 7.5 million

10 Napoleonic Wars
When: 1803-15
Belligerents: Many European nations
Death toll: 3.5-7 million

40

The amount of minutes that the shortest war in history lasted. The honour belongs to the Anglo-Zanzibar War of 1896

The Battle of Waterloo ended Napoleon's rule



The Battle of Stalingrad in 1942-43 alone saw two million soldiers killed, missing or injured



THE 10 LONGEST WARS

01

Three Hundred and Fifty Years' War

Belligerents: Isles of Scilly, Netherlands
1651-1986

This 'conflict' started during the English Civil War, when a Dutch fleet declared war on the royalist Scilly Isles. A peace treaty was finally signed in 1986.

04

Greco-Persian War

Belligerents: Greek city states, Persian empire
499-449BC

The city states of Greece overcame seemingly impossible odds in repelling a series of invasions launched by the full might of the Persian empire.

02

Arauco War

Belligerents: Colonial Spanish, Mapuche people
1536-1820s

This clash between the indigenous people of Chile and Spanish colonists ended in native victory when Chile won its independence in the 1820s.

05

Guatemalan Civil War

Belligerents: Guatemalan military, leftist rebels
1960-96

One of history's longest civil wars was sparked when dissidents rebelled against Guatemala's autocratic regime in 1960. It ended with a peace treaty in 1996.

07

Wars of the Roses

Belligerents: Houses of York and Lancaster
1455-85

England's ruling Plantagenet family tore itself apart in a bitter dynastic war that ended with Richard III's death at the Battle of Bosworth.

09

Great Northern War

Belligerents: Swedish empire, a coalition led by Russia
1700-21

Sweden's stranglehold on the areas around the Baltic Sea was smashed by a coalition of nations including Russia, Denmark-Norway and Saxony-Poland.

10

Vietnam War

Belligerents: Communist and anti-communist forces
1956-75

North Vietnam's communist forces defeated their southern neighbours and dealt the United States a bloody nose in a Cold War conflict that cost hundreds of thousands of lives.

03

Hundred Years' War

Belligerents: England, France, Burgundy, Scotland
1337-1453

English attempts to seize the throne of France were foiled in this long-running conflict that awakened French nationalism.

06

Thirty Years' War

Belligerents: Protestants and Catholic nations across Europe
1618-48

Millions died and huge areas of central Europe were laid to waste when Europe's Protestant and Catholic states crossed swords.

08

Peloponnesian War

Belligerents: Athens, Sparta
c 431-404BC

Sparta became the dominant force in the Greek world after triumphing over Athens in a series of clashes on land and sea.

The Vietnam War was both lengthy and bloody



10 BAFFLING HISTORICAL MYSTERIES

Nazca Lines

Where: Southern Peru
Created: 300BC-AD 600
Discovered: 1930s

These extraordinary ground markings depicting animals and plants – some over 200m long – have puzzled scientists for decades. Some have even claimed they're ancient runways for visiting aliens.



Runways for aliens?
The Nazca Lines of Peru

Piri Reis map

Where: Topkapı Palace, Istanbul, Turkey
Created: 1513
Discovered: 1929

How did a 16th-century Turkish mariner map northern Antarctica – the continent wasn't visited until 1818? Just one of the questions posed by Piri Reis' remarkable cartography.

Chou Chou buckle

Where: China
Created: around AD 300
Discovered: 1956

Aluminium wasn't isolated until the 19th century. So how was this girdle fastener – found in the grave of Chinese general Chou Chou – created 15 centuries earlier and made from 85% aluminium?

According to legend, Nan Madol was built by twin sorcerers



City of Nan Madol

Where: Micronesia
Created: 12th-13th century AD
Discovered: early 19th century

This once-great city – dubbed the 'Venice of the Pacific' and constructed using 250 million tonnes of huge basalt blocks on a coral reef – was made without machines. The question is: how?

Mary Celeste

Where: Atlantic Ocean
Discovered: December 1872

When this brigantine was discovered drifting, unmanned, in the Atlantic Ocean a great maritime mystery was born. Did the crew abandon the ship fearing an explosion, after smelling alcohol fumes?

Jack the Ripper murders

Where: Whitechapel, London
When: 1888

The violent murders of several prostitutes in East London triggered one of the most famous whodunnits in history as the police hunted the elusive killer 'Jack the Ripper'.

Rongorongo writing

Where: Easter Island
Created: late 18th century

Inscriptions on stone and wooden tablets found on Easter Island are in a script called rongorongo, a mix of ideographs and a kind of phonetic alphabet. But what does it mean?

Roanoke colony abandonment

Where: Roanoke Island, North Carolina, USA
Created: 1587

An English colony was established on Roanoke Island in 1587. Three years later, when John White returned with supplies, he found the colony abandoned, its population having mysteriously vanished.

Phaistos disc

Where: Phaistos, Crete
Created: Second millennium BC
Discovered: 1908

Scientists have been trying (and failing) to decipher the code on this 15cm fired-clay disc – discovered at the site of a Bronze Age Minoan palace – for over a century.

Egyptian aeroplane

Where: Saqqara, Egypt
Created: c 2000BC
Discovered: 1898

Discovered in a tomb, this remarkably aerodynamic model was designed by ancient Egyptians, 4,000 years before man could fly.



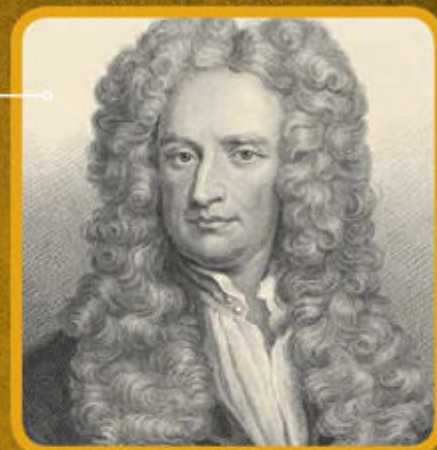
10 Famous Physicists

Isaac Newton

1643-1727

- Outlined the principle of gravity

In 1667, Newton published *Philosophiæ Naturalis Principia Mathematica* (Mathematical Principles of Natural Philosophy), which included his laws of motion and of universal gravitation.



Niels Bohr

1885-1962

- Constructed the modern model of the atom

In 1922, the Danish scientist won a Nobel Prize for his work elucidating the structure of the atom. He proposed that electrons revolve around a nucleus, and can jump from one orbit to another.

Albert Einstein

1879-1955

- Developed the general theory of relativity

'The world's most famous equation', $E=mc^2$ (energy equals mass times the speed of light squared), demonstrates the equivalence of mass and energy - just part of the German physicist's general theory of relativity.

James Clerk Maxwell

1831-79

- Introduced the concept of electromagnetism

The Scottish mathematical physicist showed that electricity, magnetism and light are all manifestations of the electromagnetic field.

Richard Feynman

1918-88

- Developed quantum electrodynamics

The American theoretical physicist won a Nobel Prize in 1965 for his work on quantum electrodynamics, but was also influential in quantum mechanics and particle physics.

Stephen Hawking

1942-present

- Revolutionised our understanding of the cosmos

Hawking's work on general relativity, quantum theory and related physical laws has transformed our understanding of the universe - especially black holes (which, he showed, shouldn't be black).

Paul Dirac

1902-84

- Predicted the existence of antimatter

The Bristol-born theoretical physicist worked on atomic theory, laid the foundations of the micro-electronics industry and won a Nobel Prize for Physics in 1933.

Max Planck

1858-1947

- Originated quantum theory

The work of this German physicist helped explain the behaviour of matter and its interaction with energy on a subatomic level. He was also influential in the wider acceptance of Einstein's special theory of relativity.

Wilhelm Röntgen

1845-1923

- Discovered X-rays

The German scientist won the first Nobel Prize for Physics in 1901 for his discovery of X-rays, which revolutionised diagnostic medicine.

Ernest Rutherford

1871-1937

- Founded the field of nuclear physics

The New Zealand-born physicist studied radiation, established the nuclear structure of the atom, theorised the existence of neutrons and became known as the 'father of nuclear physics'. He won the Nobel Prize for Chemistry in 1908.



Russia, the world's largest country, stretches across nine time zones.

PHOTO: ALAMY

HUMAN PLANET



The world is shaped by us - our houses, our cities, our roads, and, most of all, our sheer number. Here we've pulled together the facts and figures that demonstrate the impact humans have made on Earth

THE 10 LARGEST COUNTRIES BY AREA

Russia

17,098,242km²



Covering much of eastern Europe and northern Asia, Russia covers - rather extraordinarily - one-eighth of the planet's land mass. Its landscape is a combination of tundra, forests, grasslands and semi-deserts, and is home to 40 UNESCO biosphere reserves. Russia is next-door neighbours with 14 other countries; its border stretches for nearly 58,000km.

02

Canada

9,984,670km²

03

USA

9,826,675km²

04

China

9,706,961km²

05

Brazil

8,514,877km²

06

Australia

7,692,024km²

07

India

3,287,590km²

08

Argentina

2,780,400km²

09

Kazakhstan

2,724,900km²

10

Algeria

2,381,741km²



THE 10 TALLEST SKYSCRAPERS

Burj Khalifa

01

Dubai, United Arab Emirates

Height: 828m

Date completed: 2009

Having been home to the world's tallest free-standing structure for nearly 4,000 years (until the Great Pyramid at Giza in Egypt was overtaken by Lincoln Cathedral in 1311), the Middle East reclaimed the title when the Burj Khalifa tower was opened in January 2010.

02

Shanghai Tower
Shanghai, China

Height: 632m

Date completed:

2014

03

Makkah Royal Clock Tower Hotel
Mecca, Saudi Arabia

Height: 601m

Date completed:

2012

04

One World Trade Center
New York City, USA

Height: 541.3m

Date completed:

2013

05

Taipei 101
Taipei, Taiwan

Height: 509m

Date completed:

2004

06

Shanghai World Financial Center
Shanghai, China

Height: 492m

Date completed:

2008

07

International Commerce Centre
Hong Kong

Height: 484m

Date completed:

2010

=08

Petronas Tower 1
Kuala Lumpur, Malaysia

Height: 452m

Date completed:

1998

=08

Petronas Tower 2
Kuala Lumpur, Malaysia

Height: 452m

Date completed:

1998

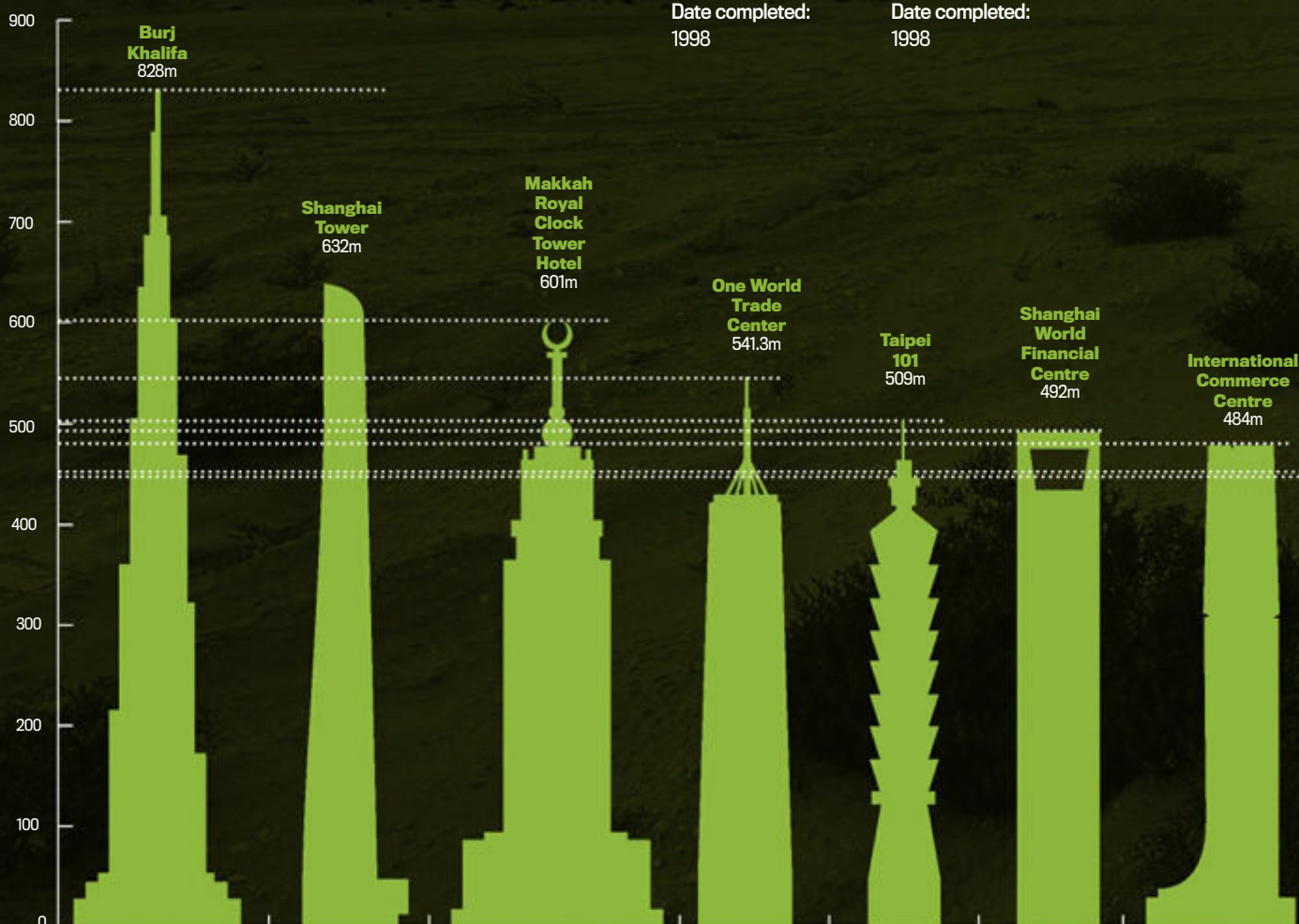
10

Zifeng Tower
Nanjing, China

Height: 450m

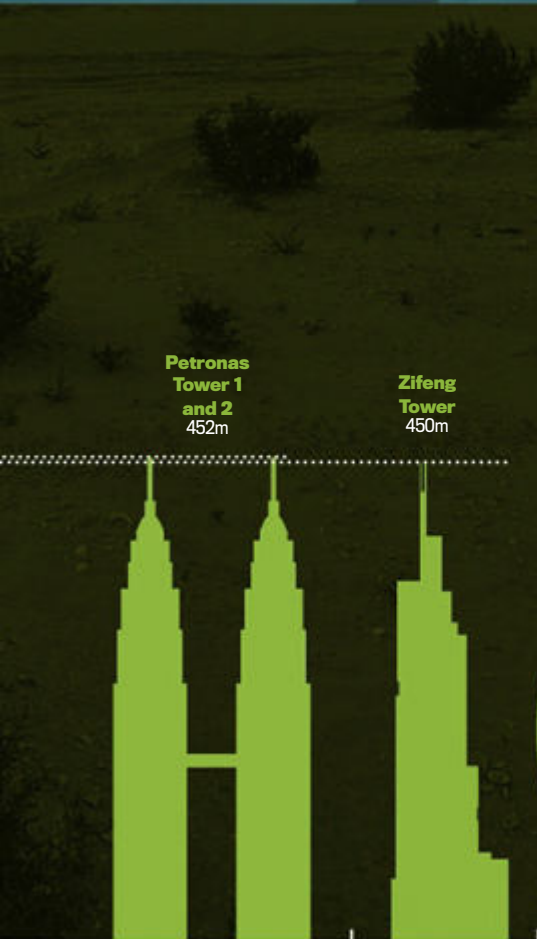
Date completed:

2010





Burj Khalifa also boasts a record-breaking number of floors – 163



DID YOU KNOW?

When it's completed in 2019, the Kingdom Tower in Jeddah in Saudi Arabia will stand 1,000 metres tall

THE 10 MOST POPULOUS COUNTRIES

01

ChinaPopulation:
1,349,585,838

02

IndiaPopulation:
1,220,800,359

03

USAPopulation:
316,438,601

04

IndonesiaPopulation:
251,160,124

05

BrazilPopulation:
201,009,622

06

PakistanPopulation:
193,238,868

07

NigeriaPopulation:
174,507,539

08

BangladeshPopulation:
163,654,860

09

RussiaPopulation:
142,500,482

10

JapanPopulation:
127,253,075

*NB: population figures estimated in July 2013. Source: CIA World Factbook



THE 10 LONGEST BRIDGES

01

Danyang-Kunshan Grand Bridge

Length: 164.8km

Location: Shanghai-Nanjing, China

Completed in 2010 and opened the following year, the world's longest bridge is this viaduct that forms one-eighth of the high-speed railway line between Beijing and Shanghai. It carries trains across the Yangtze River Delta, a watery landscape dominated by paddy fields, canals and lakes.

02

Tianjin Grand Bridge

Length: 113.7km

Location: Hebei, China

03

Weinan Weihe Grand Bridge

Length: 79.7km

Location: Weinan, China

04

Bang Na Expressway

Length: 54km

Location: Bangkok, Thailand

05

Beijing Grand Bridge

Length: 48.2km

Location: Beijing, China

06

Lake Pontchartrain Causeway

Length: 38.4km

Location: Louisiana, USA

07

Manchac Swamp Bridge

Length: 36.7km

Location: Louisiana, USA

08

Hangzhou Bay Bridge

Length: 36km

Location: Zhejiang, China

09

Yancun Bridge

Length: 35.8km

Location: Beijing, China

10

Runyang Bridge

Length: 35.6km

Location: Jiangsu, China

The Danyang-Kunshan Grand Bridge carries high-speed trains between Beijing and Shanghai

The Lake Pontchartrain Causeway carries southbound I-90 traffic into New Orleans

DID YOU KNOW?

In 2013, 102 million vehicles used the George Washington Bridge between Manhattan and New Jersey



10 COUNTRIES THAT DON'T OFFICIALLY EXIST



Republic of Somaliland

Where: Horn of Africa

Capital: Hargeisa

Declared independence from Somalia in 1991. Not recognised internationally.

Nagorno-Karabakh Republic

Where: Surrounded by Azerbaijan

Capital: Stepanakert

Declared independence in 1991, though still claimed by Azerbaijan and not recognised by most nations, except three that are also non-UN members.

Pridnestrovian Moldavian Republic (Trans-Dniester)

Where: Between Moldova and Ukraine

Capital: Tiraspol

Declared independence from Moldova in 1990; not recognised by most nations, except three that are also non-UN members.

Republic of Abkhazia

Where: Black Sea coast between Georgia and Russia

Capital: Sukhumi

Declared independence from Georgia in 1999, and has subsequently been recognised by states including Russia, Nicaragua, Venezuela, Nauru, Tuvalu and three others themselves not recognised by the UN.



Republic of China (Taiwan)

Where: South China Sea

Capital: Taipei

Effectively independent since the end of the Chinese civil war in 1949, Taiwan is recognised by only 21 UN members and the Holy See.

Sahrawi Arab Democratic Republic (Western Sahara)

Where: Between Morocco and Mauritania

Capital: Laayoune

Republic declared in 1976, but Western Sahara is still claimed by Morocco, which still governs the majority of its territory.

Turkish Republic of Northern Cyprus

Where: Northern third of Cyprus

Capital: North Nicosia/Lefkosa

Declared independence in 1983, following Turkish invasion of Cyprus. Recognised as a state only by Turkey.

State of Palestine

Where: West Bank of Jordan and Gaza Strip

Capital: Ramallah/East Jerusalem

Declared independent by the Palestine Liberation Organization. Around two-thirds of UN member states have recognised Palestine.



Republic of Kosovo

Where: Balkans, between Serbia and Albania

Capital: Pristina

Declared independence from Serbia in 2008 following long-running conflict. Recognised by USA and many Western European nations, but not by all UN members.

Republic of South Ossetia

Where: North of Georgia

Capital: Tskhinvali

Declared independence from Georgia in 1991, but recognised by only a few countries including Russia, Nicaragua and some European nations, but not all UN members.



DID YOU KNOW?

The world's lowest-lying capital city is Baku in Azerbaijan, which lies at 28m below sea level

La Paz, the Bolivian capital, clings to the lower slopes of the Andes

THE 10 SMALLEST COUNTRIES (by area)

01

Vatican City
0.4km²



02

Monaco
1.9km²



03

Nauru
21km²



04

Tuvalu
26km²





THE 10 HIGHEST CAPITAL CITIES

01

La Paz
Bolivia
3,640m



Sitting in a bowl with mountains on all sides, the Bolivian capital is located in the valleys of the Andes. With a population of 877,363, the city's more affluent citizens tend to reside in its lower-lying neighbourhoods, while poorer residents make their homes at higher altitudes within the capital.



02

Quito
Ecuador
2,850m

03

Thimphu
Bhutan
2,648m

04

Bogotá
Colombia
2,625m

05

Addis Ababa
Ethiopia
2,355m

06

Asmara
Eritrea
2,325m

07

Sana'a
Yemen
2,250m

08

Mexico City
Mexico
2,240m

09

Nairobi
Kenya
1,795m

10

Kabul
Afghanistan
1,790m



05

San Marino
61.2km²



06

Liechtenstein
160km²



07

Marshall Islands
181km²



08

Saint Kitts and Nevis
269km²



09

Maldives
298km²



10

Malta
316km²





THE 10 MOST DENSELY POPULATED COUNTRIES

01

Monaco

Area: 2.02km²

Population: 36,136 **Density:** 18,068 people/km²



Not only are its citizens the most tightly packed-in on the planet, the principality also claims the highest gross domestic product per capita at \$153,177 US. The world's second smallest country by area after the Vatican City, Monaco is modestly increasing in size thanks to ongoing land reclamation projects.

02

Singapore

Area: 716km²

Population:

5,399,200

Density: 7,669 people/km²

03

Vatican City

Area: 0.44km²

Population:

800

Density: 1,818 people/km²

04

Bahrain

Area: 757km²

Population:

1,234,571

Density: 1,631 people/km²

05

Malta

Area: 315km²

Population:

416,055

Density: 1,321 people/km²

06

Maldives

Area: 298km²

Population:

317,280

Density: 1,065 people/km²

07

Bangladesh

Area:

147,570km²

Population:

152,518,015

Density: 1,034 people/km²

08

Palestine

Area:

6,020km²

Population:

4,420,549

Density: 734 people/km²

09

Taiwan

Area:

36,191km²

Population:

23,361,147

Density: 645 people/km²

10

Barbados

Area: 430km²

Population:

274,200

Density: 638 people/km²

Monaco is no place for those who suffer from claustrophobia



THE 10 COUNTRIES MOST AFFECTED BY CLIMATE CHANGE



01

Honduras

Climate Risk Index: 10.17

Droughts and floods hit food production.

02

Myanmar

Climate Risk Index: 11.83

Warmer temperatures have led to huge increases in the spread of water-borne diseases.

03

Haiti

Climate Risk Index: 16.83

The number and power of hurricanes have increased significantly in recent years.

04

Nicaragua

Climate Risk Index: 17.17

Two category-five storms in the past 15 years claimed thousands of lives.

05

Bangladesh

Climate Risk Index: 19.67

Frequent flooding of the Ganges delta wipes out crops, destroys homes and spreads diseases.

06

Vietnam

Climate Risk Index: 24.00

Increases in flash floods, landslides and other natural disasters causing many deaths.

07

Philippines

Climate Risk Index: 31.17

Increasingly frequent, intense natural disasters, especially floods, are claiming thousands of lives.

=08

Dominican Republic

Climate Risk Index: 31.33

Flooding and erosion are both causing major problems for this Caribbean country.

=08

Mongolia

Climate Risk Index: 31.33

In the past 70 years, average temperatures have increased by 2°C and rainfall has decreased, hitting the agricultural sector particularly hard.

10

Thailand

Climate Risk Index: 31.50

Crops have been increasingly destroyed by floods.



Floodwater causes damage in Dhaka, Bangladesh

*NB: figures based on German Watch Long-Term Climate Risk Index



The Chernobyl disaster rendered Pripjat a ghost town

10 CITIES LEFT ABANDONED



Pripjat

Where: Ukraine

Abandoned: 1986

Following the Chernobyl nuclear disaster, the entire population of around 50,000 residents were evacuated – never to return.

Oradour-sur-Glane

Where: France
Abandoned: 1944

A German Panzer division destroyed this town, killing 642 inhabitants.

Kolmanskop

Where: Namibia
Abandoned: 1954

This mining town was abandoned when its diamond yield declined.

Craco

Where: Italy
Abandoned: 1963

The instability of the hill on which the town sat caused a mass exodus during the 1960s.

Varosha

Where: Cyprus
Abandoned: 1974

This holiday playground of the rich was abandoned after the invasion by Turkey.

Kayaköy

Where: Turkey
Abandoned: 1923

The non-Muslim inhabitants of this town were forced to relocate after the Greco-Turkish War.

Hashima Island

Where: Japan
Abandoned: 1974

This mining area closed for business after the seams were mined out.

Humberstone

Where: Chile
Abandoned: 1961

Abandoned after the saltpeter-mining industry declined. Now a UNESCO World Heritage Site.

Salton Riviera

Where: California
Abandoned: 1970s

Local fish population died out; so did local tourism.

Plymouth

Where: Montserrat
Abandoned: 1995

A volcanic eruption in 1995 led to the evacuation of two-thirds of the island.

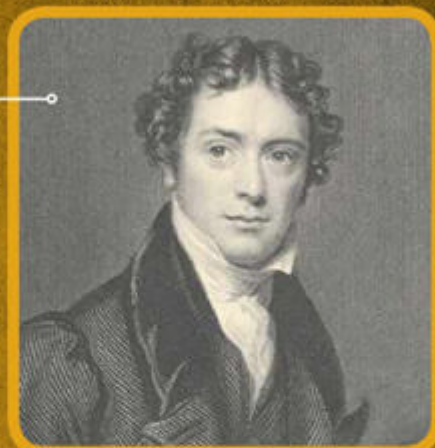
10 Famous Chemists

Michael Faraday

1791-1867

i Pioneer in the practical use of electricity

Working in electromagnetism and electrochemistry, Faraday discovered the principles of electrolysis and electromagnetic induction, invented an early form of the Bunsen burner and invented electromagnetic rotary devices.



Marie Curie

1867-1934

i Discovered radioactivity and radium

A double Nobel Prize, Polish-French Curie discovered radium and studied the radioactivity emitted by it.

Joseph Priestley

1733-1804

i Discovered oxygen (probably)

Englishman Priestley isolated a number of 'airs' (gases), including oxygen - or 'dephlogisticated air' as he called it.

John Dalton

1766-1844

i Developed atomic theory

Dalton proposed the theory that elements varied in size and mass, and produced a primitive table of relative atomic weights.



Antoine Lavoisier

1743-94

i Recognised and named oxygen and hydrogen

The Frenchman's meticulous experiments put the emphasis on quantitative science.



Robert Boyle

1627-91

i Helped found modern chemistry

This Irish chemist developed Boyle's law, describing the inversely proportional relationship between the absolute pressure and volume of a gas within a closed system at a constant temperature.

Humphry Davy

1778-1829

i Discovered sodium and potassium

A pioneer in the field of electrolysis, Cornishman Davy discovered several new earth metals and elements, including sodium, potassium, magnesium, boron and barium.

Mario Molina

1943-present

i Pioneering work in chlorofluorocarbon gases

Along with Frank Sherwood Rowland, Molina conducted a significant amount of research into CFCs, in the process discovering the hole in the ozone layer over the Antarctic.

Jöns Jacob Berzelius

1779-1848

i Developed the modern system of chemical formula notation

The Swede devised a system abbreviating Latin names to one or two letters with superscripts showing the number of atoms of each element.

Dmitri Mendeleev

1834-1907

i Formulated periodic law and the periodic table

The Russian discovered recurring patterns within each group of elements in his periodic table when all the known chemical elements were arranged in order of atomic weight.

The Falcon HTV-2 could travel from coast to coast across the US in just 12 minutes

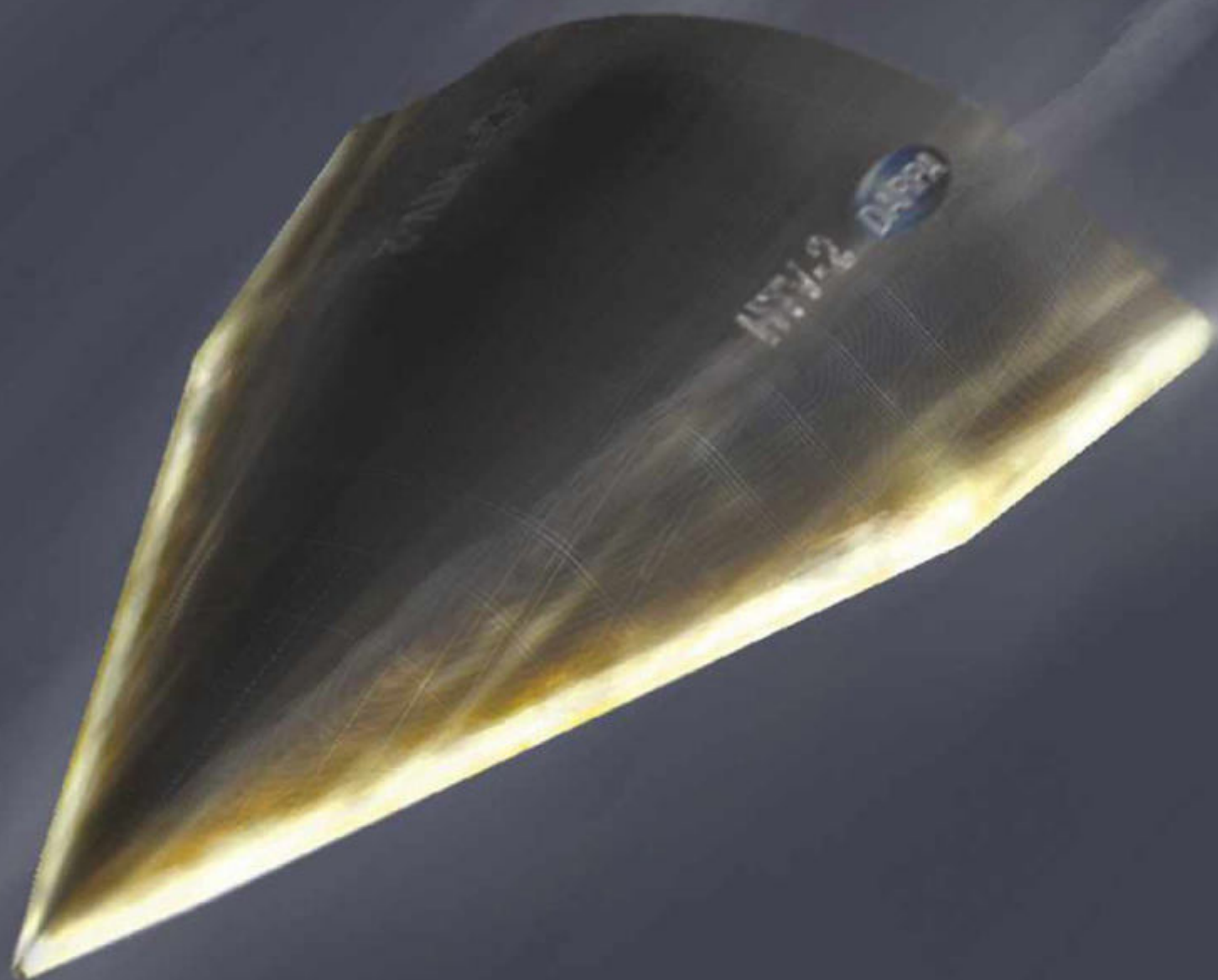


PHOTO: US AIR FORCE/DARPA

TRANSPORT



The past 100 years or so have seen an extraordinary revolution in the way that we move around our planet. Almost always, the emphasis has been to reach more places - and to do it faster...

THE TOP 10 FASTEST PLANES

Falcon HTV-2

01

Top speed: 20,920km/h

Unmanned

Lockheed Martin, Defense Advanced Research Projects Agency and US Air Force, USA, 2010

Developed to test the limits of long-duration hypersonic travel, the Falcon HTV-2 is a rocket-launched, unmanned but fully manoeuvrable plane that's capable of flying at Mach 20. Not that anything can be remotely described as 'long-duration' at these kinds of speed; a plane travelling at more than 20,000 miles an hour would cover the distance between New York City and Los Angeles in around 12 minutes.

02

X-43A

Top speed:
12,144km/h

Unmanned
NASA, USA,
2004

03

X-15

Top speed:
7,274km/h

Manned
US Air Force
and NASA, USA,
1959

04

X-51

WaveRider

Top speed:
6,276km/h

Unmanned
Boeing, USA,
2010

05

SR-71

BlackBird

Top speed:
3,540km/h

Manned
Lockheed, USA,
1964

06

MiG-25

Foxbat

Top speed:
3,492km/h

Manned
Mikoyan-
Gurevich, Soviet
Union, 1964

07

Bell X-2

Starbuster

Top speed:
3,369km/h

Manned
Bell Aircraft,
USA, 1955

08

XB-70

Valkyrie

Top speed:
3,308km/h

Manned
North American
Aviation, USA,
1964

09

MiG

Foxhound

Top speed:
2,999km/h

Manned
Mikoyan, Soviet
Union, 1975

10

F-15 Eagle

Top speed:
2,679km/h

Manned
McDonnell
Douglas,
Boeing, Space
& Security,
USA, 1972

THE 10 LONGEST METRO SYSTEMS

01

Seoul Metropolitan Subway South Korea

Total length: 952km **Opened:** 1974



The South Korean capital's metro system doesn't just boast the longest track network, it also contains the largest number of stations - 615 located along 19 separate lines. Renowned for both its cleanliness and its efficiency, the subway serves around 10 million commuters on a daily basis. And it doesn't stop there. Line extensions - and new lines - are planned for the next few years.



02

Shanghai Metro China

Total length: 538km
Opened: 1993

03

Munich S-Bahn Germany

Total length: 530km
Opened: 1972

04

Beijing Subway China

Total length: 456km
Opened: 1971

05

London Underground UK

Total length: 402km
Opened: 1863

06

New York City Subway USA

Total length: 373km
Opened: 1868
(elevated section)

07

Berlin S-Bahn Germany

Total length: 332km
Opened: 1924

08

Moscow Metro Russia

Total length: 317.5km
Opened: 1935

09

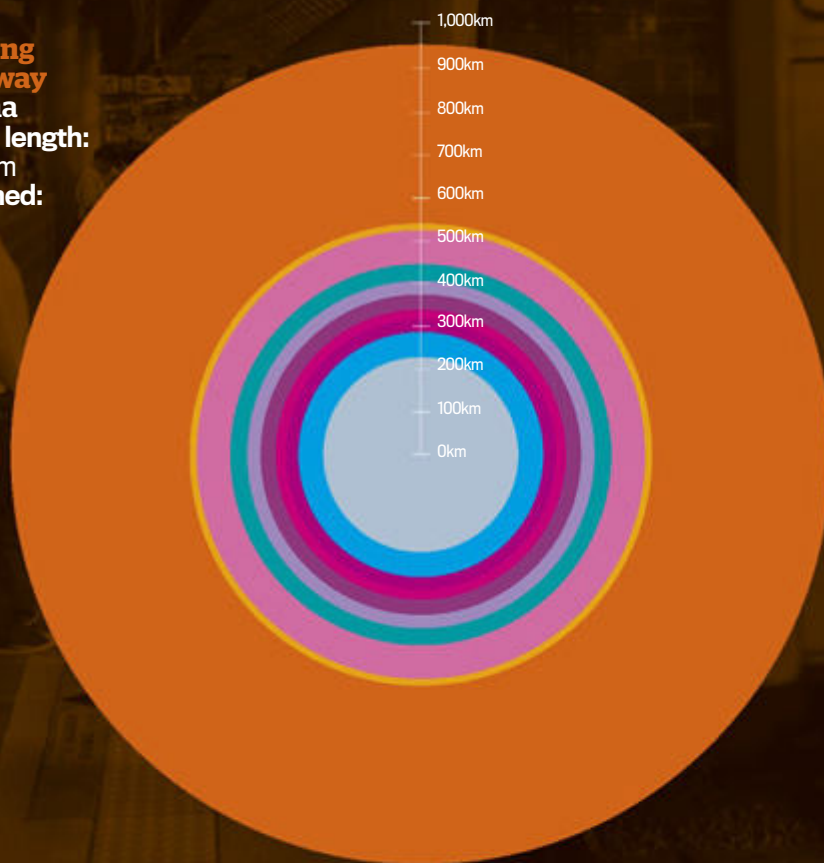
Metro de Madrid Spain

Total length: 293km
Opened: 1919

10

Guangzhou Metro China

Total length: 240km
Opened: 1997



The world's longest metro systems

Seoul Metropolitan Subway 952km	New York City Subway 373km
Shanghai Metro 538km	Berlin S-Bahn 332km
Munich S-Bahn 530km	Moscow Metro 317.5km
Beijing Subway 456km	Metro de Madrid 293km
London Underground 402km	Guangzhou Metro 240km

THE 10 FASTEST ROAD CARS

01

Bugatti Veyron Super Sport

Top speed: 431km/h
2010-present

Despite having made its public debut back in 2010, all other road-legal cars continue to eat the Super Sport's cinders. Powered by an eight-litre engine, the Bugatti is capable of accelerating from 0-60mph in just 2.4 seconds. This need for speed doesn't come cheap, though. Prospective owners need to have a spare \$2.5m in their back pocket. And then there's those insurance premiums...



02

**Hennessey
Venom GT**
Top speed:
428km/h
2012-present



03

**Koenigsegg
Agera R**
Top speed:
418km/h
2011-present



04=

**SSC Ultimate
Aero**
Top speed:
413km/h
2006-2013



04=

9ff GT9-R
Top speed:
413km/h
2007-2008



06

**Saleen S7
Twin-Turbo**
Top speed:
399km/h
2005-2009



07

**Koenigsegg
CCX**
Top speed:
394km/h
2006-2010



08

McLaren F1
Top speed:
386km/h
1992-1998



09

Zenvo ST1
Top speed:
374km/h
2009-present



10

**Pagani
Huayra**
Top speed:
370km/h
2012-present

10 GREAT TRANSPORT BREAKTHROUGHS

01 Wheel c 4500BC

It's difficult to pinpoint when the wheel was invented, but the earliest recorded evidence of their use dates back to the Sumerians of Mesopotamia. The wheel enabled the people of this ancient civilisation to build carts with which to haul bigger loads than could be carried on their backs.

02 Sailboat c 4000BC

The Nile, Tigris and Euphrates rivers were important trade routes for the Egyptians and Mesopotamians. Artefacts from those civilisations show sailboats were used to travel and to transport goods between the settlements along them.

03 Suspension c 3100BC

Early roads were little more than rocky tracks, making journeys uncomfortable for any passengers and potentially damaging for cargo. By hanging a load-bearing platform or cabin from a frame built upon a cart's chassis, the ancient Egyptians came up with a method of ensuring a smoother ride.

04 Chain drive c300BC

The mechanism that - by transmitting drive from one place to another - would dramatically alter bicycle design approximately 2,000 years later first appeared in ancient Greece. The polybolos, an automatic crossbow, used a chain drive to load bolts for rapid and repeated fire.

05 Rockets c 1250

Long before some bright spark thought of using rockets to launch a men and machines into space, they were being used as weapons in battle. After they invented gunpowder, Chinese chemists used it to fire incendiary projectiles at their enemies.



THE 10 LONGEST COMMERCIAL FLIGHTS



01

Sydney to Dallas
13,804km
Qantas
15 hours and 10 minutes



02

Johannesburg to Atlanta
13,582km
Delta Air Lines
16 hours and 55 minutes



03

Dubai to Los Angeles
13,420km
Emirates
16 hours and 30 minutes



04

Dallas to Brisbane
13,363km
Qantas
16 hours

**06 Steam locomotion
1784**

Steam engines were the driving force behind the Industrial Revolution, but the idea for using boiling water as a power source dates back long before the 18th century. However, it wasn't until 1784 that Scottish inventor William Murdoch unveiled a prototype of a steam-powered road vehicle. Trains and ships would follow soon after.

**09 Powered flight
1903**

Man had been taking to the skies using various forms of kites, gliders and balloons for a long time before Orville and Wilbur Wright showed up. But they were the first to successfully make a powered, controlled and sustained flight.

**07 Pneumatic tyre
1845**

A 'tier' was the name given to the band of steel used to tie the spokes on wooden wheels together to form the round structure. But steel isn't the best material for producing traction or a comfortable ride so people began looking for an alternative, which arrived in the form of vulcanised rubber. Scotsman Robert William Thomson was the first to patent the idea of attaching a rubber tyre to a wheel and filling it with air.

**08 Internal combustion engine
1879**

The roots of the internal combustion engine date back centuries. Crank and rod mechanisms appear in Roman times and gunpowder was used to drive the pistons of a water pump in the 17th century. However, it was Germany's Nikolaus Otto who first built and patented an internal combustion engine that could be incorporated into an automobile.

**05**

Dubai to Houston
13,144km
Emirates
16 hours and 20 minutes

**06**

Dubai to San Francisco
13,041km
Emirates
16 hours

**07**

New York (JFK) to Hong Kong
12,990km
Cathay Pacific
16 hours

**08**

New York (Newark) to Hong Kong
12,980km
United Airlines
15 hours and 50 minutes

**09**

Doha to Houston
12,951km
Qatar Airways
16 hours and 20 minutes

**10**

Dubai to Dallas
12,940km
Emirates
16 hours and 20 minutes

THE 10 BIGGEST COMMERCIAL AIRCRAFT

01



Airbus A380
853 passengers
72.72m long

02



Boeing 747-8
700 passengers
76.3m long

03



Boeing 747-400
568 passengers
70.6m long

04



Boeing 777-300
550 passengers
73.9m long

06



Boeing 747-200
452 passengers
70.6m long

06



Boeing 747-100
452 passengers
70.6m long

08



Boeing 777-200
440 passengers
63.7m long

09



Airbus A350-1000
369 passengers
73.78m long



430
km/h



380
km/h



360
km/h



350
km/h

01

Shanghai Maglev, China
Route: Longyang Road Station - Shanghai Pudong International Airport
Opened: 2004
Manufacturer: Siemens and ThyssenKrupp

02

Harmony CRH 380A, China
Route: Beijing - Shanghai
Opened: 2010
Manufacturer: CSR Qingdao Sifang Locomotive & Rolling Stock

03

AGV Italo, Italy
Route: Naples - Milan
Opened: 2012
Manufacturer: Alstom

04

Velaro E/AVS 103, Spain
Route: Barcelona - Madrid
Opened: 2007
Manufacturer: Siemens

THE 10 FASTEST TRAINS

THE 10 BUSIEST AIRPORTS

05



Boeing 747-300
496 passengers
70.6m long

10



Airbus A340-600
359 passengers
75.36m long



01 Atlanta International Airport, USA
95,462,867 passengers in 2012

02 Beijing Capital International Airport, China
81,929,359 passengers in 2012

03 London Heathrow Airport
70,037,417 passengers in 2012



04 Tokyo International Airport
66,795,178 passengers in 2012

05 O'Hare International Airport, Chicago, USA
66,633,503 passengers in 2012

06 Los Angeles International Airport, USA
63,688,121 passengers in 2012

07 Paris Charles de Gaulle Airport, France
61,611,934 passengers in 2012



08 Dallas-Fort Worth International Airport, USA
58,591,842 passengers in 2012

09 Soekarno-Hatta International Airport, Jakarta, Indonesia
57,772,762 passengers in 2012

10 Dubai International Airport, UAE
57,684,550 passengers in 2012



350
km/h

=04

Talgo 350, Spain
Route: Madrid - Lleida
Opened: 2005
Manufacturer: Patentes Talgo and Bombardier Transportation



320
km/h

=06

E5 Series Shinkansen Hayabusa, Japan
Route: Tohoku Shinkansen Line
Opened: 2011
Manufacturer: Kawasaki Heavy Industry and Hitachi



320
km/h

=06

Alstom Euroduplex
Route: France, Germany, Switzerland, Luxembourg, Spain
Opened: 2011
Manufacturer: Alstom



320
km/h

=06

TGV Duplex, France
Route: Paris - Marseille
Opened: 1996
Manufacturer: Alstom and Bombardier



320
km/h

=06

ICE 3, Germany
Route: Frankfurt - Cologne; Munich - Nuremberg
Opened: 2000
Manufacturer: Siemens



300
km/h

10

ETR 500 Frecciarossa, Italy
Route: Rome - Milan
Opened: 2008
Manufacturer: Treno Veloce Italiano

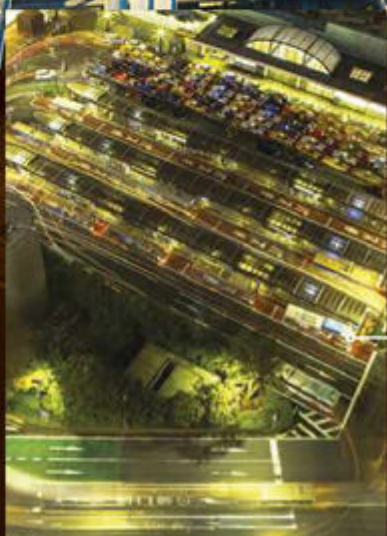
* Source: Airports Council International (www.aci.aero) preliminary passenger figures 2012.

THE 10 COUNTRIES WITH THE MOST AIRPORTS



THE 10 LARGEST RAILWAY NETWORKS





THE 10 COUNTRIES WITH THE LONGEST ROAD NETWORKS

- 01  **USA**
Distance: 6,586,610km
- 02  **India**
Distance: 4,689,842km
- 03  **China**
Distance: 4,106,387km
- 04  **Brazil**
Distance: 1,580,964km
- 05  **Russia**
Distance: 1,283,387km
- 06  **Japan**
Distance: 1,210,251km
- 07  **Canada**
Distance: 1,042,300km
- 08  **France**
Distance: 1,028,446km
- 09  **Australia**
Distance: 823,217km
- 10  **Spain**
Distance: 683,175km

09

France
Distance:
29,640km

10

Brazil
Distance:
28,538km

 USA 224,792km	 Germany 41,981km
 China 100,000km	 Australia 38,445km
 Russia 87,157km	 Argentina 36,966km
 India 63,974km	 France 29,640km
 Canada 46,552km	 Brazil 28,538km

DID YOU KNOW?


Ninety per cent of Londoners live within 400m of at least one of the capital's 19,500 bus stops



10 Famous

Transport pioneers

**Isambard
Kingdom Brunel**
1806-59

 **Trains, boats, bridges...**
He could do it all

As well as building the first railway linking London to Bristol, this visionary engineer also designed both the Clifton Suspension Bridge in Bristol and the SS *Great Britain*, the first iron steamer to cross the Atlantic.

George Stephenson

1781-1848

i Became renowned as the 'father of railways'

Stephenson built the world's first public inter-city railway line to use steam locomotives. His design for the Rocket also became the template for most steam engines in the following 150 years.

Henry Ford

1863-1947

i Founded the Ford Motor Company

This industrialist's adoption of mass-production techniques revolutionised transport, with his Model T Fords rolling off the assembly line at an astonishing rate. Ford was a controversial character, but made car ownership an achievable goal for many middle-class Americans.



Wright brothers

Orville: 1871-1948

Wilbur: 1867-1912

i Made the first powered fixed-wing flight

At the turn of the 20th century, the race to achieve powered flight was heating up. But though several of their contemporaries got airborne at around the same time, these siblings were the first to achieve true powered flight - on 17 December

Sir Christopher Cockerell

1910-99

i Invented the hovercraft

The British owner of a small boat company, Cockerell wanted his vessels go faster. He developed a theory - that a narrow jet of air around the edge of a craft would efficiently lift it above the water - and tested his ideas with a vacuum cleaner and two tin cans, patenting his technology in 1955. The

Montgolfier brothers

Joseph-Michael: 1740-1810

Jacques-Étienne: 1745-99

i Invented the hot-air balloon

In 1783 - 120 years before the Wright brothers made history - these French siblings flew an unmanned balloon nearly 2km during a public demonstration, following that with a brief (tethered) flight with Étienne on board.

Wernher von Braun

1912-77

i Developed rocket science

Lauded as the 'father of rocket science', this German-American was a crucial figure in the development of the V-2 rocket used by the Germans in the Second World War. He was subsequently recruited by NASA and became chief architect of the Saturn V launch vehicle.



Pierre Lallement

1843-1891

i Invented the bicycle

Many people have laid claim to being the creator of the bicycle, including Scottish blacksmith Kirkpatrick Macmillan in 1839. But Frenchman Lallement was the first to be awarded a patent in the US in 1866 after adding pedals to a walk-along dandy horse to create the velocipede.

Frank Whittle

1907-96

i Invented the turbojet engine

Whittle outlined the principles behind jet propulsion while still a student, taking out a patent on his design in 1930 at the tender age of 23. The first prototype was produced in 1937, and the first jet-powered plane, a Gloster E.28/29, took its maiden flight on 15 May 1941.

Karl Benz

1844-1929

i Invented the petrol-powered automobile

Though other engineers (including fellow German Gottlieb Daimler) were working on similar vehicles concurrently, in 1886 Benz was the first to be awarded a patent for an automobile powered by an internal combustion engine.



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LONGEST? WHAT IS THE LONGEST HUMAN SPACE FLIGHT? WHICH
IS THE FASTEST? HOW MANY BONES ARE THERE IN A HUMAN FOOT?
WHAT IS THE LARGEST COUNTRY? WHAT ARE THE BIGGEST SCIENTIFIC
MIRACLES? WHAT WAS HYPATIA WELL-KNOWN FOR? WHO DISCOVERED
URANUS? WHAT PERCENTAGE OF THE UK POPULATION OWNS A
SMARTPHONE? HOW MANY AIRPORTS DOES PARAGUAY HAVE? WHEN
DID HUMANS FIRST MAKE STONE TOOLS? HOW LONG IS THE LONDON
UNDERGROUND SYSTEM? WHO INVENTED THE HOVERCRAFT?
WHICH PLANE IS THE FASTEST? HAVE ANY SCI-FI PREDICTIONS EVER
COME TRUE? HOW LONG WAS THE LONGEST WAR? WHAT ARE THE
LOWEST POINTS ON LAND? HOW SHORT WAS NAPOLEON? WHAT ARE
THE MOST WIDELY SPOKEN LANGUAGES? WHO DISCOVERED SUPER
HEROES? WHICH ANIMAL HAS THE MOST UNUSUAL MATING PRACTICE?
WHO DISCOVERED RADIOACTIVITY? WHAT DID THALES DISCOVER
IN 580BC? WHICH PLANET HAS THE BIGGEST MOON? WHAT IS THE
MOST EXPENSIVE SCIENCE EXPERIMENT? WHO WAS THE TALLEST
HUMAN? HOW MANY PEOPLE LIVE IN CHINA? WHAT ARE THE TALLEST
WATERFALLS? HOW BIG IS THE LARGEST GALAXY? WHAT ARE THE
LARGEST PARASITES? WHO HAS THE LONGEST TONGUE IN THE WORLD?
WHO MAPPED THE COASTLINE OF AUSTRALIA? HOW BIG IS THE BIGGEST
TELESCOPE? WHERE ARE THE LARGEST LAKES? WHO INVENTED
FOAM? WHAT IS THE BRIGHTEST STAR IN THE UNIVERSE? WHICH
IS THE HIGHEST CAPITAL CITY ON THE PLANET? WHO DISCOVERED
DNA? WHAT IS THE OLDEST CITY IN THE WORLD? WHAT ARE THE
BIGGEST EXPLOSIONS ON EARTH? WHEN WAS PAPER INVENTED?
WHAT ARE THE LARGEST DESERTS? WHAT WERE THE DEADLIEST
VOLCANIC ERUPTIONS? WHAT ARE THE BIGGEST AIRPORTS? WHAT
IS THE TALLEST SKYSCRAPER? WHAT ARE THE BIGGEST BREAKTHROUGHS
IN GEOLOGY? HOW MANY PEOPLE DIED IN THE SECOND WORLD WAR?
WHAT IS THE OLDEST ANIMAL? WHAT ARE THE BIGGEST ASTEROID
IMPACTS ON EARTH? WHICH COUNTRY HAS BUILT THE MOST POWERFUL
NUCLEAR REACTOR? WHO FIRST DISCOVERED THE REMAINS OF A T-REX? WHEN
WAS THE LONGEST BRIDGE? WHAT ARE THE TOP HISTORICAL MYSTERIES?
WHICH COUNTRIES ARE MOST AFFECTED BY CLIMATE CHANGE? WHICH
ANIMAL HAS THE MOST PAINFUL STING? WHAT IS THE BEST HISTORICAL
ADVICE? WHERE ARE THE HOTTEST PLACES ON EARTH? WHAT IS THE
LARGEST ANIMAL? CAN YOU SURVIVE WITH JUST ONE LUNG?
WHAT WAS THE LARGEST EMPIRE? HAVE ANY INVENTORS BEEN KILLED
BY THEIR OWN INVENTIONS? WHAT IS THE BIGGEST EXOPLANET?
WHAT LANGUAGES ARE FACING EXTINCTION? HOW MANY PASSENGERS
CAN FIT ON AN AIRBUS A380? WHAT IS THE FARTHEST ANIMAL
MIGRATION? WHAT SPECIES HAS THE BEST EYESIGHT? WHERE IS THE
OLDEST PLACE? HOW FAST IS A PEREGRINE FALCON? WHAT ARE THE
MOST POWERFUL SUPER COMPUTERS? WHAT IS THE MOST DENSELY
POPULATED COUNTRY? HOW MANY PEOPLE SPEAK ESPERANTO? WHO
WAS THE FIRST PERSON TO WALK ON THE MOON? WHAT WAS UNDER A MICROSCOPE
IN 1665? HOW FAST IS THE FASTEST TRAIN? HOW DANGEROUS ARE MOSQUITOES?
WHICH COUNTRIES DON'T EXIST? WHAT IS THE FARTHEST A SPACE
ROBOT HAS TRAVELLED? WHAT IS THE BIGGEST ISLAND? WHO WAS
THE FIRST WOMAN IN SPACE? WHO INVENTED THE WHEEL? WHEN WAS

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